Dark Skies/Light Impact Assessment

Methodology Report

South Oxfordshire and Vale of White Horse

Final Report

Prepared by LUC and Hoare Lea

July 2024

Version	Status	Prepared	Checked	Approved	Date
1	Draft Report	J Bournazel	C Green	D Manson	31/07/2023
2	Updated draft report	J Bournazel R Swann	D Manson	D Manson	23/10/2023
3	Interim methodology report	J Bournazel	D Manson	D Manson	13/12/2023
4	Final report	J Bournazel	D Manson	D Manson	29/07/2024

ISO 14001:2015 Environmental Management EMS566057
ISO 9001:2015 Quality Management FS566056
OHSAS 18001 Occupational Health and Safety Management OHS627041
IEMA Transforming the world to sustainability - EIA -
Landscape Institute Registered Practice

Land Use Consultants Limited

Registered in England. Registered number 2549296. Registered office: 250 Waterloo Road, London SE1 8RD. Printed on 100% recycled paper

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- AONB: Areas of Outstanding Natural Beauty, now called National Landscape.
- BS EN: A BS standard is a British or UK regulatory code or standard. EN is the European regulatory standard, BS EN is the British adoption of EN standards with some changes.
- CIE : Commission Internationale de l'Eclairage (International Commission on Illumination).
- Dark sky reserve: Public or private land possessing an exceptional or distinguished quality of starry nights and nocturnal environment that is specifically protected for its scientific, natural, educational, cultural, heritage and/or public enjoyment- see IDA.
- Direct sky glow: The direct upward spill of light into the sky, which can cause a 'glowing' effect and is often seen above cities when viewed from a dark area.
- Electromagnetic spectrum: The entire range of wavelengths of all known electromagnetic radiations. Radiation is energy that travels and spreads out as it moves. For Geographic Information System (GIS) applications, the wavelength of light determines its colour. Light with wavelength 400-500 nanometres (nm) is blue light, 500-600 nm is green and 600-700 nm is red, which is the visible portion of the electromagnetic spectrum.
- Environmental Zones (EZ): The characteristics are defined in CIE 150:2017 and ILP Guidance Note GNO1/21. Lighting design parameters depend upon the definition of the environmental zone as stated in these documents. (Refer to Table 6 a).
- GIS: Geographical Information System
- Glare: A visual discomfort caused by excessive brightness or uncontrolled light sources, which can impair visibility and cause discomfort to the eyes.

Glossary of general dark skies, lighting and planning terms

- IDA: International Dark-Sky Association: The recognised authority on light pollution and is the leading organisation combating light pollution worldwide.
- Illuminance: Calculated as the density of lumen's per unit area and is expressed using lux (lumen's/square metre). Illuminance can be measured using a light metre.
- ILP: Institution of Lighting Professionals.
- LED (Light-Emitting Diode): A semiconductor device that emits light when an electric current passes through it. LEDs are energy-efficient and have a longer lifespan compared to traditional light sources.
- LIA: Light Impact Assessment.
- Lighting master plan: A comprehensive plan that outlines the long-term vision and strategy for lighting within a city, town, or region. It includes guidelines for different types of lighting, such as street lighting, architectural lighting, and landscape lighting, to create a cohesive and sustainable lighting environment.
- Light pollution: The excessive or misdirected artificial light produced by human activities that adversely affects the natural darkness of the night sky and interferes with the environment, human health, and astronomical observations.
- Light Spill (vertical and horizontal): The spilling of light beyond the boundary of a property, which may cause nuisance to others.
- Lumen (lm): The unit of luminous flux, a measure of the total quantity of visible light emitted by a source per unit of time.
- NOAA: United States National Oceanic and Atmospheric Administration
- Pixel: The unit of information in an image file or map, usually square or rectangular, holding the data value.
- Radiance: The variable directly measured by remote sensing instruments. Radiance is how much light the instrument detects from the object being observed.

- Receptors: Light sensitive receptors are often sub categorised as - ecological, human, heritage and transport. Different receptors have various degrees of tolerance to increased light levels.
- Skyglow: The brightening of the night sky caused by scattered and upward-directed artificial light. It reduces visibility of stars, constellations, and other celestial objects.
- SLL: Society of Light & Lighting.
- Site: Proposed development area, usually denoted by a “red-line” boundary.
- SQM: Sky quality metre, measures the darkness of the night sky in magnitudes per square arcsecond.
- Steradian (sr): The radiance units are measured in nanowatts/centimetre squares (cm^2)/sr where sr is steradians. A steradian is a section of a sphere where the surface area is equal to the radius of the full sphere. It represents the surface area required by a detector to detect the full radiant flux (energy) at any given distance. Also refer to Appendix D.
- Suomi NPP: Suomi National Polar-orbiting Partnership, refers to a weather satellite operated by NOAA launched in October 2011.
- Sun-synchronous polar-orbiting satellite: a type of satellite travelling over the polar regions always in the same fixed position relative to the sun.
- UNESCO: United Nations Educational, Scientific and Cultural Organisation.
- VIIRS: Visible Infrared Imaging Radiometer Suite. This is an instrument on a satellite that captures visible and infrared imagery to monitor processes such as wildfires, ice motion, cloud cover, and land and sea surface temperature.
- Watt (W): A unit of electrical power that measures the rate at which energy is consumed by a light source.

Chapter 1

Executive summary

Study context

1.1 In January 2023, South Oxfordshire and Vale of White Horse District Councils commissioned LUC to produce landscape evidence contributing to the Joint Local Plan that will guide development in the districts to 2041.

1.2 The first requirement of this landscape evidence is the production of a new dark skies / light impact assessment which will inform the other elements of the updated landscape evidence. This evidence will identify the darkest areas of the districts which need the strongest protection from light pollution. The evidence also supports an understanding of the levels of light pollution in other areas in the districts to prevent it from worsening.

What is the aim of this study?

1.3 This assessment was commissioned out of recognition of the importance of minimising light pollution to reduce the impact on the environment, people and landscapes in South Oxfordshire and Vale of White Horse Districts, and to preserve the dark skies quality of the districts.

1.4 This study involved the production of:

- A map showing dark skies and sky glow in South Oxfordshire and Vale of White Horse using satellite data.
- A set of key findings and statistics for the two local authorities and the National Landscapes (formerly known as Areas of Outstanding Natural Beauty or AONBs).

- An evidence-based framework of environmental lighting zones.

1.5 The GIS outputs from this study are hosted online in an interactive dark skies/light pollution map **[See reference 1]**.

1.6 This report provides an overview of the relevant legislative and policy context. It details the method used to create the dark skies map and presents the headline figures and statistics extracted from the map. Finally, it describes the process of identifying Environmental Zones in the districts.

1.7 Future work will be undertaken to develop supporting guidance for the use of the dark skies mapping when considering lighting proposals.

Overview of key findings

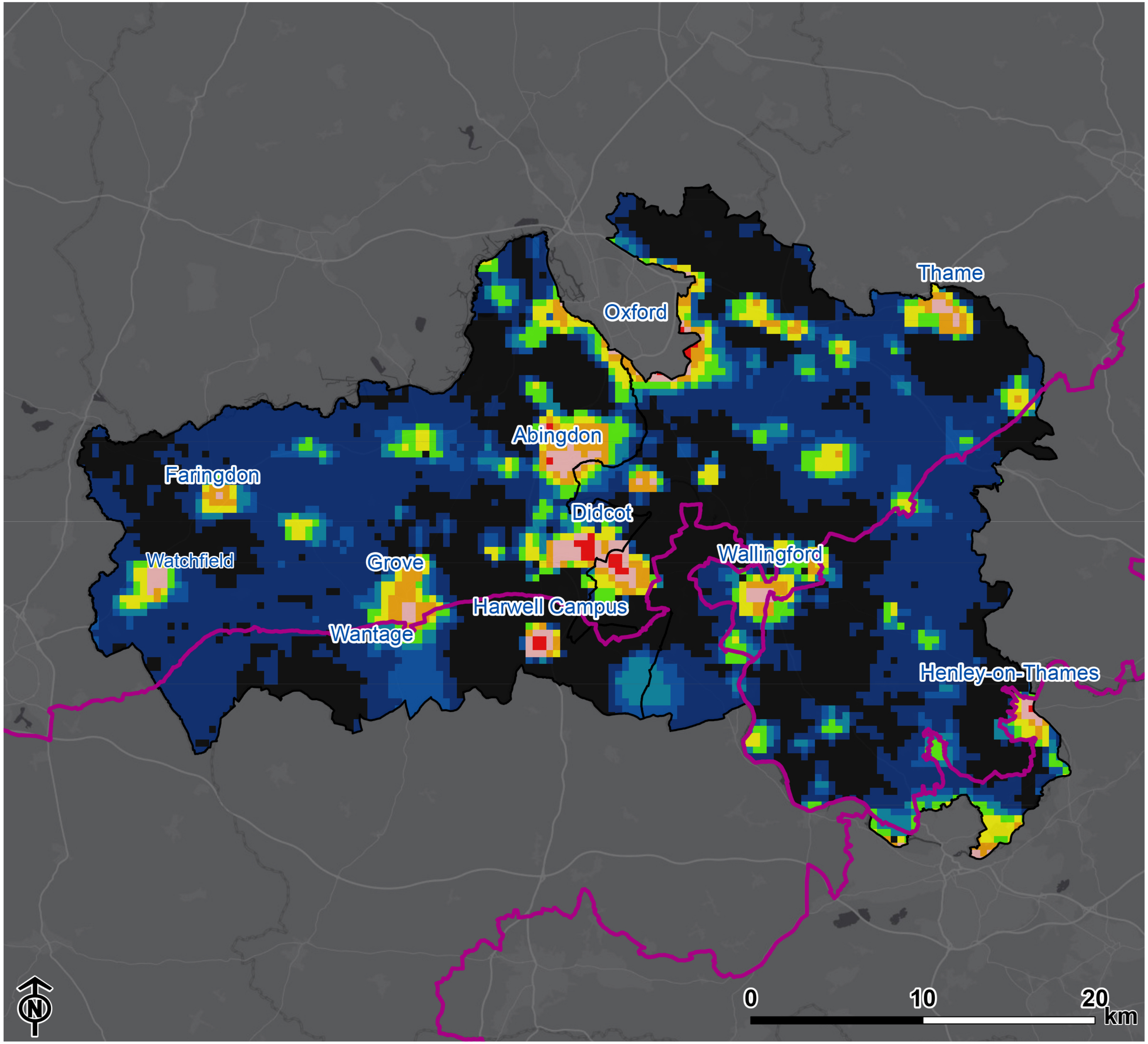
1.8 The resultant dark skies and light pollution map is shown in **Figure 1.1**. Headline statistics include:

- 74.6% of South Oxfordshire and Vale of White Horse falls within the darkest sky category (<0.25 NanoWatts/cm2/sr).
- Only 0.3% of the study areas falls within the second brightest category (16-32 NanoWatts/cm2/sr), and none of the study area falls in the brightest (>32 NanoWatts/cm2/sr).
- Both districts have a similar profile across the brightness categories, with South Oxfordshire having a higher percentage of land falling within darker categories.
- The National Landscapes experience little sky glow with 91.7% of Chilterns and 90.1% of North Wessex Downs falling in the two darkest categories (<0.5 NanoWatts/cm2/sr).

Dark Skies Assessment
South Oxfordshire and Vale of White Horse Councils

LUC

Figure 1.1: Dark Skies and Light Pollution



South Oxfordshire and Vale of White Horse

National Landscape

Night Lights (NanoWatts / cm2 / sr)

- >32
- 16 - 32
- 8 - 16
- 4 - 8
- 2 - 4
- 1 - 2
- 0.5 - 1
- 0.25 - 0.5
- < 0.25 (highest 50%)
- < 0.25 (lowest 50%)

Brightest

Darkest

Map scale 1:325,000 @ A4

1.9 Using the Institute of Lighting Professionals (ILP) framework for categorising Environmental Zones **[See reference** 2**]**, the two districts have been categorised into the following Environmental Zones based on the brightness data on the dark skies map:

- E1 (Natural dark zone);
- E2 (Rural low district brightness zone);
- E3 (Suburban medium district brightness zone); and
- E4 (Urban high district brightness zone).

1.10 Future work will produce guidance which shows how lighting development proposals could be considered in relation to their impacts on dark skies and identifies general principles that can be put in place to protect and enhance dark skies as well as reduce and mitigate light pollution.

Chapter 2

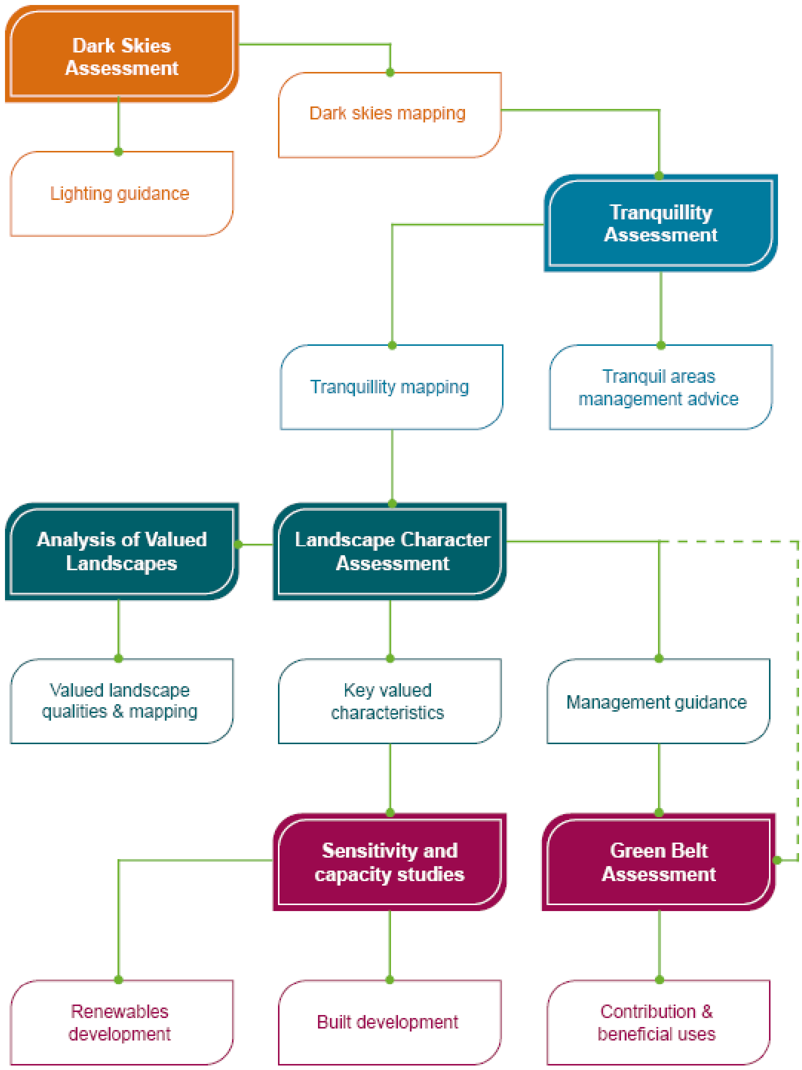
Introduction

2.1 In January 2023, South Oxfordshire and Vale of White Horse District Councils commissioned LUC to produce landscape evidence contributing to the Joint Local Plan that will guide development in the districts to 2041. An overview of the suite of landscape evidence commissioned is shown in **Figure 2.1**.

2.2 The first requirement of this landscape evidence was the production of a new dark skies / light impact assessment to inform the other elements of the updated landscape evidence.

2.3 For this assessment, environmental lighting specialists Hoare Lea provided specialist input.

Figure 2.1: Suite of landscape evidence bases



What is light pollution?

2.4 Light pollution (sometimes referred to as ‘obtrusive light’) is the excessive or misdirected use of artificial light produced by human activities that can disrupt the natural darkness of the night sky and interferes with the environment, human health, and astronomical observations.

2.5 As stated by the Institution of Lighting Professionals (ILP) in GN01/21 Guidance Notes for the Reduction of Obtrusive Light **[See reference 3]**:

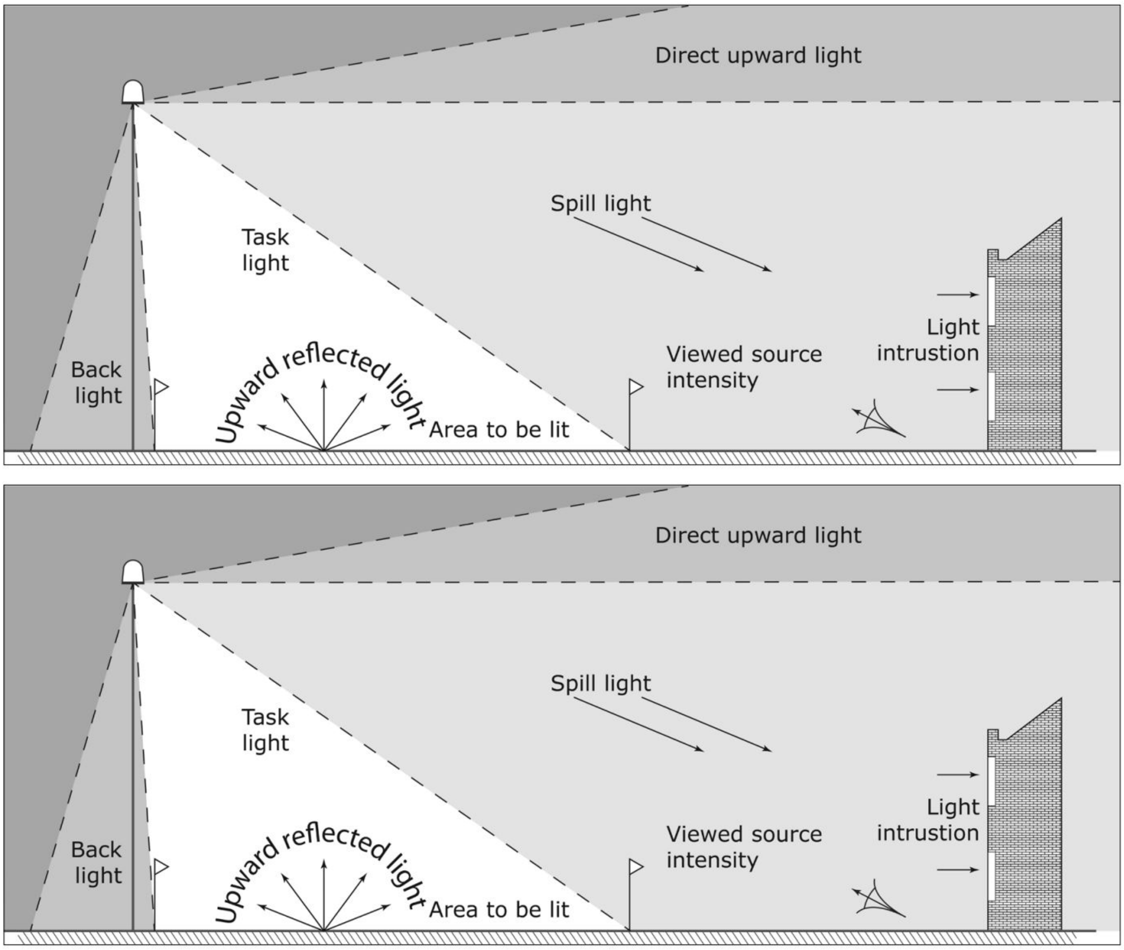
'Obtrusive light, whether it keeps you awake through a bedroom window, impedes your view of the night sky or adversely affects the performance of an adjacent lighting installation, is a form of pollution. It may also be a nuisance in law and can be substantially mitigated without detriment to the requirements of the task'.

2.6 The ILP provide Guidance Notes: PLG 04 Guidance on undertaking environmental lighting impact assessments **[See reference 4]** and GN01/21 Guidance Notes for the Reduction of Obtrusive Light **[See reference 5]**. This guidance supports quantifiable assessment of light pollution such that lighting limitations can be applied to the following:

- Sky glow: is the brightening of the night sky.
- Glare: is the uncomfortable brightness of a light source when viewed against a darker background.
- Light spill: is the spilling of light beyond the boundary of the area being lit.

2.7 Light intrusion ('nuisance') is all forms of obtrusive light which may cause nuisance to others, or adversely affect fauna and flora as well as waste money and energy.

Figure 2.2: Illustration of the types of obtrusive light



Source: ILP GN01/21 Guidance Notes for the Reduction of Obtrusive Light

Visual or landscape intrusion from lighting

2.8 The view of a lit site at night, potentially when there was no lighting previously, may cause visual intrusion and adversely affect landscape character, but does not in itself constitute light pollution as defined under the ILP's guidance GN01/21 – The Reduction of Obtrusive Light. In technical terms, light pollution does not include the observation of a lit site from a distance, if the three elements that make up light pollution, namely light spill, glare and sky glow, have been controlled in accordance with current guidance.

Qualitative/visual impacts of lighting

2.9 Dark skies contribute to perceived tranquillity, which is an important and valued component of landscape character, and sense of place. They contribute to an increased sense of 'naturalness', through seeing stars, and limiting lighting can also enhance nocturnal wildlife activity and promote a sense of 'time-depth'.

2.10 The Guidelines for Landscape and Visual Impact Assessment (Third Edition, 2013, Landscape Institute and the Institute of Environmental Assessment and Management) **[See reference** 6**]** notes at Paragraph 6.12 that "Quantitative assessments of illumination levels, and incorporation into models relevant to visual effects assessment, will require input from lighting engineers, but the visual effects assessment will also need to include qualitative assessments of the effects of the predicted light levels on night-time visibility."

Why is this evidence required?

2.11 Light pollution is known to have a significant impact on both wildlife and humans. Dark skies are most often associated with rural environments. As predominantly rural districts, it is important to understand where the darkest areas are, and conversely understand where light pollution may be negatively affecting the night sky and landscape character. The evidence will be used to support the preservation of existing dark skies as well as stop it from worsening in all areas.

2.12 Whilst a national map of dark skies **[See reference** 7**]** was produced in 2016 by CPRE, the Countryside Charity, up-to-date evidence on dark skies and light pollution is of assistance to inform the preparation of a local plan.

Aims and objectives

2.13 The aims of this study are to:

- Create a map showing dark skies and sky glow in South Oxfordshire and Vale of White Horse using the latest available satellite data.
- Produce key findings/statistics for the two local authorities using the new dark skies and light pollution map.
- Develop an evidence-based framework of environmental lighting zones.
- Host the dark skies/light pollution map online to show this information in a visually engaging and easy to understand way.

2.14 This study uses a methodology that aligns well with the approach used to develop the national map of dark skies and light pollution (CPRE, 2016 **[See reference** 8**]**).

Structure of this report

2.15 This report is structured in the following way:

- **Chapter 2**: Introduction – provides the background to the study and sets out the aims of the assessment.
- **Chapter 3**: Legislation and guidance – provides an overview of the relevant legislative and policy context. This section introduces guidance that is relevant to the study. This is supported by Appendix A.
- **Chapter 4**: Creating the map – sets out a summary of the method used to generate the map from satellite data. This is supported by more detail in Appendices B to D.
- **Chapter 5**: Headline figures and statistics – this section provides some interpretation of the mapped data. Results are presented as tables and graphs as well as maps. This section is supported by Appendix E.

- **Chapter 6**: Identifying Environmental Zones – this section provides information on the Institute of Lighting Professionals (ILP) approach to categorising Environmental Zones. It then goes on to describe the process of identifying Environmental Zones in the districts and some analysis of the outputs. Information on how to access the online map is provided.

Chapter 3

Legislation and guidance

Legislation and planning policy

3.1 The issue of light pollution was introduced within the Clean Neighbourhoods and Environment Act 2005 (CNEA) as a form of statutory nuisance under the Environmental Protection Act (the 'EPA', 1990), which was amended in 2006 to include the following nuisance definition:

- "(fb) artificial light emitted from premises so as to be prejudicial to health or nuisance."

3.2 The CNEA does not recommend how to control light pollution. Further guidance is given on the Government website **[See reference** 9**]** which specifically points to Department for Environment Food and Rural Affairs (Defra) for further guidance (no longer available online). Considerations on what constitutes artificial lighting nuisance are provided by Defra **[See reference** 10**]**; providing guidance to councils on how to deal with complaints.

3.3 Although light was described as having the potential to cause statutory nuisance (see also the Statutory Nuisance Statement (Document Ref. 5.9)), no prescriptive limits or rules were set for impact assessment purposes. Guidance Notes for the Reduction of Obtrusive Light produced by the Institution of Lighting Professionals **[See reference** 11**]** have therefore been referred to for the purposes of this document.

3.4 Guidance produced on Section 101 to Section 103 of the Clean Neighbourhoods and Environment Act 2005 **[See reference** 12**]** places a duty on local authorities to ensure that their areas are checked periodically for existing and potential sources of statutory nuisances – including nuisances arising from artificial lighting. Local authorities must take reasonable steps to investigate complaints of such nuisances from artificial light. Once satisfied that a statutory nuisance exists, or may occur or reoccur, local authorities must issue an abatement notice (in accordance with Section 80(2) of the EPA 1990), requiring that the nuisance cease or be abated within a set timescale.

3.5 It is a requirement of the Conservation of Habitats and Species Regulations 2017 **[See reference** 13**]** (as amended) ('the Habitats Regulations') that plans and projects are subject to an Appropriate Assessment if it is likely that they will lead to significant adverse effects on a Natura 2000 site (the collective name for European designated sites). Impacts from lighting are also relevant to the Habitats Regulations Assessment (HRA).

National Planning Policy Framework (NPPF)

3.6 The NPPF (2023) states in paragraph 185 that planning policies and decisions should ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:

- "limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation."

Local planning policy

3.7 Local authority (South Oxfordshire **[See reference** 14**]** and Vale of White Horse **[See reference** 15**]**) policies and landscape evidence should be referred to when developing any exterior lighting scheme.

3.8 Existing policies relevant to lighting in the adopted South Oxfordshire Local Plan include:

- Objective 8 Climate Change

- Policy STRAT 10: Berinsfield Garden Village – specifically requests of smart street lighting that avoids night sky light pollution.
- Policy ENV11: Pollution - Impact from Existing and/or Previous Land Uses on New Development (Potential Receptors of Pollution)
- Policy ENV12: Pollution - Impact of Development on Human Health, the Natural Environment and/or Local Amenity (Potential Sources of Pollution)
- Policy DES6: Residential Amenity
- Policy DES7: Efficient Use of Resources

3.9 Existing policies in the adopted Vale of White Horse Local Plan include:

- Part 1 Core Policy:
  - 37: Design and Local Distinctiveness.
  - 44: Landscape
- Part 2 Development Policy:
  - 21: External Lighting
  - 22: Advertisements

3.10 When the Joint Local Plan is adopted with its new policies on light pollution, this will supersede the current adopted Local Plans for South Oxfordshire and Vale of White Horse.

3.11 Policies within Neighbourhood Plans (true as of November 2023) in the districts that relate to lighting/light pollution include:

- South Oxfordshire:
  - Culham Neighbourhood Plan – CUL10 Light Pollution **[See reference** 16**]**
  - Dorchester-on-Thames Neighbourhood Development Plan – DoT14 Peace and Tranquillity **[See reference** 17**]**

- East Hagbourne Neighbourhood Development Plan – Policy VC6 Lighting **[See reference** 18**]**
- Goring Neighbourhood Plan – Policy.13 – Light Pollution **[See reference** 19**]**
- Shiplake NDP Neighbourhood Plan – Policy SV12 – Dark Skies and Lighting **[See reference** 20**]**
- Tiddington-with-Albury NDP Neighbourhood Plan – Policy TwA11: Dark Skies **[See reference** 21**]**
- Wallingford NDP Neighbourhood Plan – Policy HD5: Avoidance of Light Pollution **[See reference** 22**]**
- Woodcote Neighbourhood Plan – Policy D2: Light Pollution **[See reference** 23**]**

- Vale of White Horse
  - Ashbury NDP Parish Neighbourhood Plan – Policy 3- Dark Night Skies **[See reference** 24**]**
  - Blewbury NDP Neighbourhood Development Plan – Policy P8- Amenity: New Development **[See reference** 25**]**
  - Chilton NDP Neighbourhood Development Plan – Policy P7: Avoidance of unnecessary light pollution **[See reference** 26**]**
  - Uffington and Baulking NDP Neighbourhood Plan – Policy D6: Dark skies **[See reference** 27**]**

3.12 The South Oxfordshire and Vale of White Horse Joint Design Guide which is adopted as a Supplementary Planning Document (SPD) can be used as a material consideration in planning decisions.

Statutory management plans for National Landscapes (formerly AONBs)

3.13 The statutory management plans for the two National Landscapes (formerly AONBs) within the district can be used as a material consideration in planning decisions.

3.14 The Chilterns AONB Management Plan **[See reference** 28**]**, which contains Policies DP8 and DP15 on lighting.

3.15 The North Wessex Downs AONB Management Plan (2019-2024) **[See reference** 29**]** which includes Chapter 7 on lighting for development. The North Wessex Downs AONB Position Statement on Dark Skies and Artificial Light **[See reference** 30**]** has been formally approved by the Council of Partners including all the constituent local authorities. This guidance forms an extension of the principles laid out within the North Wessex Downs AONB Management Plan.

Relevant lighting standards and guidance

3.16 A number of publications lay down the best practice and guidance on providing sufficient and appropriate lighting. These tend to fall into two categories:

- Commission Internationale de l'Eclairage (International Commission on Illumination) (CIE), British, European (BS EN) and other documents which offer guidance on lighting levels required for a safe and secure site for end users.
- Light Pollution guidance which is there to ensure that any lighting installed is designed to minimise the impact on sensitive receptors.

3.17 Below are just a few examples of documents that may be relevant when designing lights for the external environment. The important point to note is that a suitably qualified lighting designer should always be consulted to ensure the correct and current standards and guidance are referenced. For more details please also refer to **Appendix A**.

3.18 Thought should also be given to the impact of light spill from buildings.

> Please note that not all guidance listed in the next sections are freely accessible.

General light pollution guidance

International guidance

3.19 Commission Internationale De L'Eclairage (CIE) 150 [See reference 31]: Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations (the 'CIE 150', 2017 2nd edition). The purpose of CIE 150 is to aid in formulating guidelines for assessing the environmental effects of exterior lighting and to provide limits for relevant lighting parameters to contain the obtrusive effects of exterior lighting to tolerable levels. CIE 150 refers to the potentially adverse effects of exterior lighting on both natural and man-made environments.

3.20 CIE 126: Guidelines for Minimising Sky Glow (1997) [See reference 32] gives general guidance for lighting designers and policy makers on the reduction of sky glow. The report gives recommendations about maximum permissible values for exterior lighting installations. These values are regarded as limiting values. Lighting designers should strive to meet the lowest criteria for the design. Practical implementation of the general guidance is left to national regulations.

3.21 Founded as the International Dark-Sky Association in 1988, **DarkSky Org [See reference 33]** is the globally recognised authority on light pollution issues and night sky conservancy.

National guidance

3.22 Institute of Lighting Professionals (ILP) Guidance Notes for the Reduction of Obtrusive Light 2021 (GN01/21) [See reference 34] reflects the changes in international guidance regarding obtrusive light as detailed in CIE 150:2017: Guide on the limitation of the effects of obtrusive light from outdoor lighting installations. It also considers industry comment regarding the assessment and definition of obtrusive lighting. The ILP has proposed lighting guidance and criteria for local authorities with a recommendation that these are incorporated at the local plan levels.

3.23 Institute of Lighting Professionals (ILP) PLG 04 Guidance on Undertaking Environmental Lighting Impact Assessments (2013) [See reference 35] aims to outline good practice in lighting design and provide practical guidance on the production and assessment of lighting impacts within new developments.

3.24 Institute of Lighting Professionals (ILP) PLG05: Brightness of Illuminated Advertisements (2023) [See reference 36] discusses the application of media screens and facades.

3.25 Bat Conservation Trust (BCT) / Institute of Lighting Professionals (ILP) – Bats and Artificial Lighting in the UK 2023 (GN 08/23) [See reference 37] is aimed at lighting professionals, lighting designers, planning officers, developers, bat workers/ecologists and anyone specifying lighting. It is intended to raise awareness of the impacts of artificial lighting on bats, and mitigation is suggested for various scenarios. However, it is not meant to replace site-specific ecological and lighting assessments.

3.26 **Landscape Institute and the Institute of Environmental Assessment and Management Guidelines for Landscape and Visual Impact Assessment (Third Edition, 2013) [See reference 38]** provides the authoritative statement of the principles of Landscape and Visual Impact Assessment (LVIA). It sets out the need for the qualitative assessment of the effects of predicted light levels on night-time visibility.

Additional light pollution guidance for consideration

3.27 **All-Party Parliamentary Group for Dark Skies: Ten Dark Sky Policies for the government [See reference 39]** sets out the major causes of light pollution in the UK and advocates policy solutions to mitigate or remedy these issues. It makes ten recommendations under the headings of:

- Update the existing legal framework.
- Supercharge standards for lighting.
- Incentivise dark sky governance at the national, local and individual level.

3.28 **Dark Skies of the North Wessex Downs: A Guide to Good External Lighting [See reference 40]** provides good practice on external lighting, primarily on buildings, but also mentions internal lighting and street lighting. It is aimed at anyone considering external lighting in and around the North Wessex Downs National Landscape (formerly AONB).

Additional considerations: the impact of interior lighting

3.29 Whilst this study focuses on exterior lighting and dark skies, it is also important to consider the impact of interior light spill.

3.30 It is important for a competent lighting professional to be consulted when developing any lighting scheme. In addition to a well-considered lighting design, additional mitigation measures such as manual or automated blinds, lighting controls and glazing light transmission (LT) could be considered to help limit interior light spilling out into the exterior environment. However these measures are not always appropriate and should be considered carefully.

3.31 A number of designated landscapes have developed detailed design guidance on good lighting aimed at providing technical advice on lighting. **The Cumbria Good Lighting Technical Advice Note (TAN) [See reference 41]** is one such document that aims to inform and empower planners, developers and residents to make good lighting choices when planning new development or installing new or replacement lighting.

General light level guidance for outdoor safety and security

International guidance

3.32 The purpose of **CIE 136:2000 Guide to the lighting of urban areas [See reference 42]** is to supplement the lighting recommendations and standards for roads and areas of public use as detailed in the Publication CIE 115-1995. It replaces CIE 92-1992 Guide to the Lighting of Urban Areas.

National guidance

3.33 BS EN 5489-1:2020 Code of practice for the design of road lighting – Part 1 Lighting of roads and public amenity areas [See reference 43] is a multi-part document divided into a number of Parts. It provides guidance and recommendations that are intended to support the BS EN 13201 series and to assist designers of lighting systems in using that standard.

3.34 **Part 42 Performance requirements (British Standard) of the European Standard BS EN 13201-4:2015 Road lighting [See reference 44]** defines, according to photometric requirements, lighting classes for road lighting aiming at the visual needs of road users, and it considers environmental aspects of road lighting.

3.35 **BS EN 12464-2:2014 Lighting of work places; Outdoor work places [See reference 45]** is a multi-part document. This British and European Standard specifies lighting requirements for outdoor workplaces which meet the needs for visual comfort and performance. All usual visual tasks are considered.

Additional guidance for consideration

3.36 **The Institute of Lighting Professionals (ILP) GN09/19 Domestic Exterior Lighting [See reference 46]** guidance note advises on how best to install domestic exterior lighting to ensure it serves the required purpose and provides the correct level of illumination.

3.37 **Institute of Lighting Professionals (ILP) PLG23 Lighting for cycling infrastructure [See reference 47]** is a comprehensive review of current lighting standards and guidance, applying them to cycling infrastructure.

3.38 Recommendations within **the guide Society of Light and Lighting (SLL) LG04 Sports Lighting 2023 [See reference 48]** have been aligned to the British Standard and European Norm (BS EN) 12193 (BSI, 2018).

3.39 The aim of the **Society of Light and Lighting (SLL) LG6 The Outdoor Environment 2016 guide [See reference 49]** is to reflect technology changes and provide readers with a firm foundation from which to approach exterior lighting design.

3.40 **FA Guide to Floodlight [See reference 50]** highlights the main issues in relation to floodlighting for football, identifying keys areas for floodlight implementation.

3.41 Sports England Artificial Sports Lighting 2012 [See reference 51] provides design guidance notes to increase awareness of good design in sports facilities, to help key building professions, clients, user representatives and other stakeholders to follow best practice and to encourage well designed sports facilities that meet the needs of sports and are a pleasure to use.

3.42 LTA Floodlight Guidance [See reference 52] provides recommended and minimum light standards for outdoor floodlit tennis courts.

3.43 FIFA Lighting Guide 2020 [See reference 53] provides standards, requirements and guidance for pitch illuminance systems at FIFA tournament stadiums and training sites.

Chapter 4

Creating the map

4.1 This section sets out the method followed to create the data and subsequent maps that support this assessment. **Appendix D** provides further detail on the approach. The level of detail provided allows for the method to be replicated in the future.

Obtaining night light imagery from satellites

4.2 In October 2011, the United States National Oceanic and Atmospheric Administration (NOAA) launched the Suomi National Polar-orbiting Partnership or Suomi NPP. This sun-synchronous polar-orbiting satellite flies over any given point on the earth's surface twice each day at roughly 1:30 a.m. and 1:30 p.m. (local solar time). The Visible Infrared Imaging Radiometer Suite (VIIRS) is one of the instruments on board this satellite and it captures visible and infrared imagery to monitor and measure processes including wildfires, ice motion, cloud cover, and land and sea surface temperature amongst other things.

4.3 The VIIRS sensor collects data in a number of channels including the Day/Night Band (DNB). The DNB sensor determines on-the-fly whether to use its low, medium or high gain mode to gather information on the amount of light emitted. By being able to alter the exposure time, if a pixel is very bright, a low gain mode on the sensor prevents the pixel from over-saturating. The opposite occurs if a pixel is dark.

Important note: Whilst the data captured by the Suomi-NPP DNB offers significant improvements over that of previous satellite programmes, the Suomi-NPP DNB lacks sensitivity at wavelengths shorter than 500 nanometres. Because of this, the blue-light emission peak of white LEDs is not detected.

This means that the “blue blindness” of the VIIRS DNB could falsely suggest a reduction in light pollution in rural and urban areas, whereas the brightness of the sky as seen by human eyes may in fact increase. This is a known limitation of this data.

The electromagnetic spectrum that is visible to the human eye is between 380 nanometres-700 nanometres and local authorities in the UK have been upgrading their street lights to LEDS since 2011.

Selecting the best data

4.4 Global monthly average night light composite images are produced by the Earth Observation Group at Colorado School of Mines. The latest monthly composite data available at the time this study was conducted was November 2022. Therefore, monthly composite data from December 2021 were downloaded for review and analysis in order to cover a full year. Each monthly dataset is supported by a second image which shows the number of cloud free nights used to make up the night light monthly average image.

4.5 To select a baseline dataset to use in the creation of the South Oxfordshire and Vale of White Horse dark skies map, all the datasets were brought into Geographic Information System (GIS) software – ESRI ArcMap. Each month was viewed alongside its cloud free composite data to establish the extent to which cloud cover was impacting the data. Months when there were a high number of nights with a lot of cloud cover over the study area were dismissed from the analysis. These maps can be seen in **Appendix B**.

4.6 After a thorough review, January 2022 was selected as the best month in terms of low influence of cloud cover and has been used to create the dark skies/light pollution map for the study area.

Data preparation and calibration

4.7 Over the lifetime of this satellite, the analytical methods used to produce this data have been altered and refined. This has had the effect of causing some variation between the different years in how sensitive the data is to low light levels. Two major changes were made in 2014 and 2017:

- From 2014 onwards, the dataset had a stray light correction applied, which means that there is less light overspill from one pixel to adjacent pixels.
- From 2017 onwards, the method of calculating radiance changed, which has the effect of areas with no, or very low, light emission levels appearing brighter than would be expected.

4.8 In order to correct for the differing sensitivity of the data the selected month was amended to improve its level of brightness. This process is called zero-point calibration.

4.9 The method for performing this calculation was adapted from that created by Coesfeld et al (2020) in the paper - Reducing Variability and Removing Natural Light from Nighttime Satellite Imagery: A Case Study Using the VIIRS DNB **[See reference 54]**. The method, as detailed in the article, covered the full globe, and involved creating a 5 degree grid of points, and micro-siting those to locations where there is no light emission, for example in the ocean or in unpopulated areas. The values of the light emission data are then measured at those points. Since it can be confirmed that there is no light emission in those locations, the difference between 0 and the actual light emission recorded gives a measure of the offset between the recorded value and reality.

4.10 The offset values across all these points were then interpolated to a global raster dataset, which is combined with the light emission dataset to perform a broad calibration to 0 of those locations that should show no emission.

4.11 As this study only covers a fraction of the globe, it was necessary to adapt the point grid to suit the smaller study area. Instead, a grid was created with points at 5-kilometre intervals, and then the same micro-siting exercise was performed as in the paper, with points being limited to moving within 2 kilometre of their original location. If no locations with zero light emission could be found within this distance, the point was removed.

4.12 The grid of points used can be seen in **Figure 4.1**. The coordinates of each point are detailed in **Appendix C**.

4.13 The data has been georeferenced and clipped in GIS to the study area boundary with an additional 6 kilometre buffer around the edge (to ensure the entire area is covered by complete pixels). The data has also been resampled to 400m x 400m pixel size.

Dark Skies Assessment
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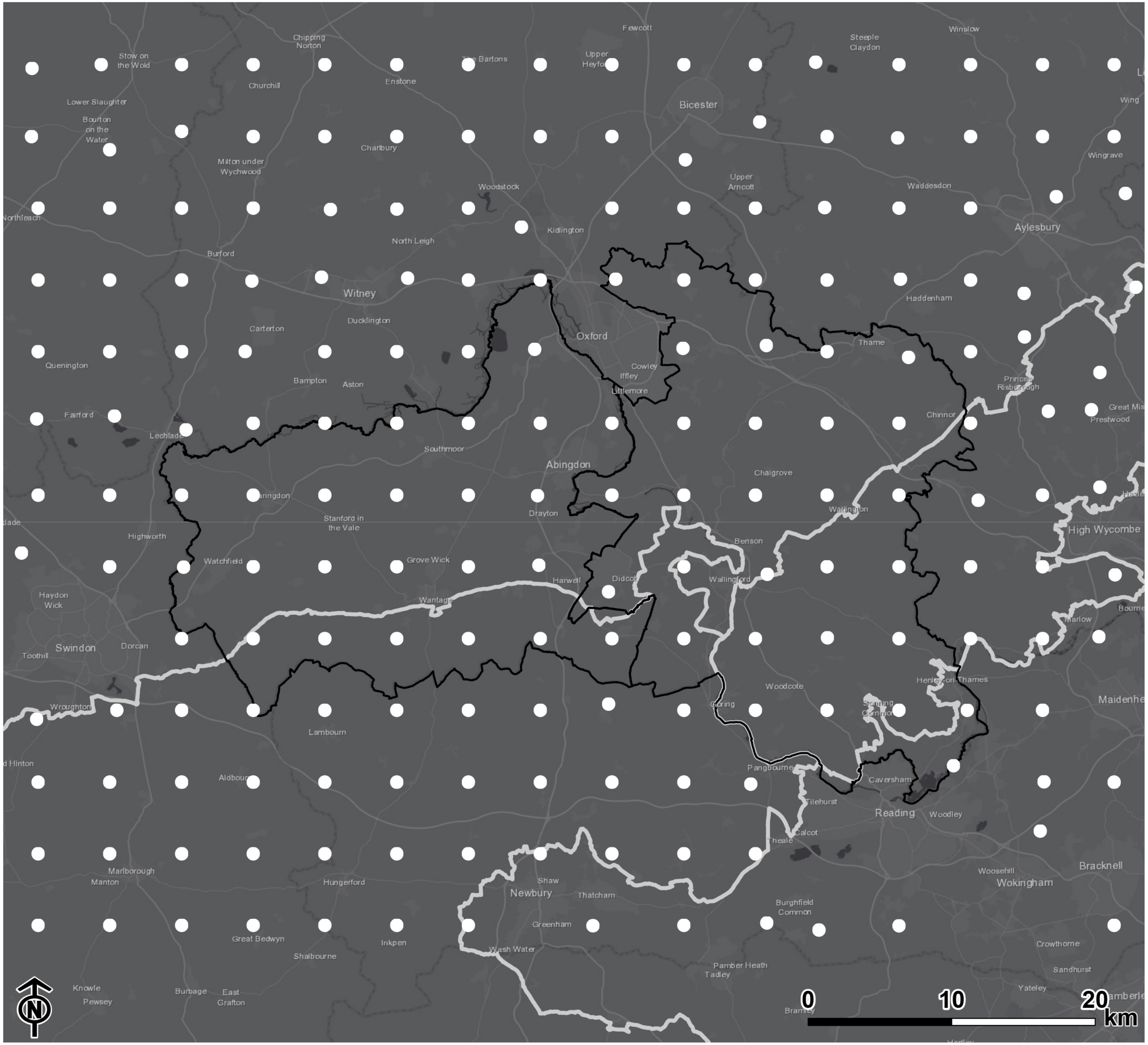
Figure 4.1: Zero-points for calibration



South Oxfordshire and Vale of White Horse

National Landscape

Zero-point

Esri UK, Esri, HERE, Garmin, USGS, Esri, HERE© Natural England copyright 2023. Contains Ordnance Survey data © Crown copyright and database right 2023, LUC

Map scale 1:390,000 @ A4

Data presentation

4.14 The units of measurement of the light pollution dataset are nanowatts per centimetre squared per steradian (nw/cm2/sr). In simple terms, the lower the value, the lower the light pollution levels (and the darker the skies are likely to be) and the higher the values, the greater the levels of light pollution. The data values were initially divided into nine colour bands ranging from dark blues (low brightness values) to dark reds (high brightness values) to match the existing national map classification.

4.15 Given the high proportion of the districts falling in the darkest category, it was considered sensible to explore differentiation within this band by creating sub-categories within the national equivalent band 1. The spread of the darkest pixels was split by quantile classification, allowing differentiation between the lowest value 50% pixels scoring <0.25 as colour band 1a, and the higher value 50% of pixels scoring <0.25 classified as colour band 1b as shown in Table 4a.

Table 4a: Colour bands and values

Colour band	Brightness values (in nw/cm2/sr)
Colour band 1a (Darkest)	<0.25 (lowest 50% values)
Colour band 1b	<0.25 (highest 50% values)
Colour band 2	0.25-0.5
Colour band 3	0.5-1
Colour band 4	1-2
Colour band 5	2-4
Colour band 6	4-8
Colour band 7	8-16

Colour band	Brightness values (in nw/cm2/sr)
Colour band 8	16-32
Colour band 9 (Brightest)	>32

4.16 Further detail on the data source, units of measurement and how the data has been processed can be found in **Appendix D**. The methodology correlates with the CPRE England's Light Pollution and Dark Skies report produced by LUC in May 2016.

Important note: Although the methodology correlates with the CPRE England's Light Pollution and Dark Skies report (2016), the 2022 satellite data used to create the current map is not comparable with the 2015 data that was used for the CPRE national map. The way the VIIRS data is processed has changed multiple times since 2016 and the calibration method applied here did not exist in 2016. Therefore, results from this report are not directly comparable to the dark skies statistics measured for districts in the CPRE report (2016).

4.17 Figure 4.2 shows the resulting Dark Skies/Light Pollution map once the data has been classified into the colour bands shown in **Table 4a**. The map clearly identifies the main concentrations of night time lights, creating light pollution that spills up into the night sky.

4.18 By contrast, the map also identifies areas where there is very little night time lighting and where the sky would be expected to be truly dark without the problems caused by light pollution.

Dark Skies Assessment
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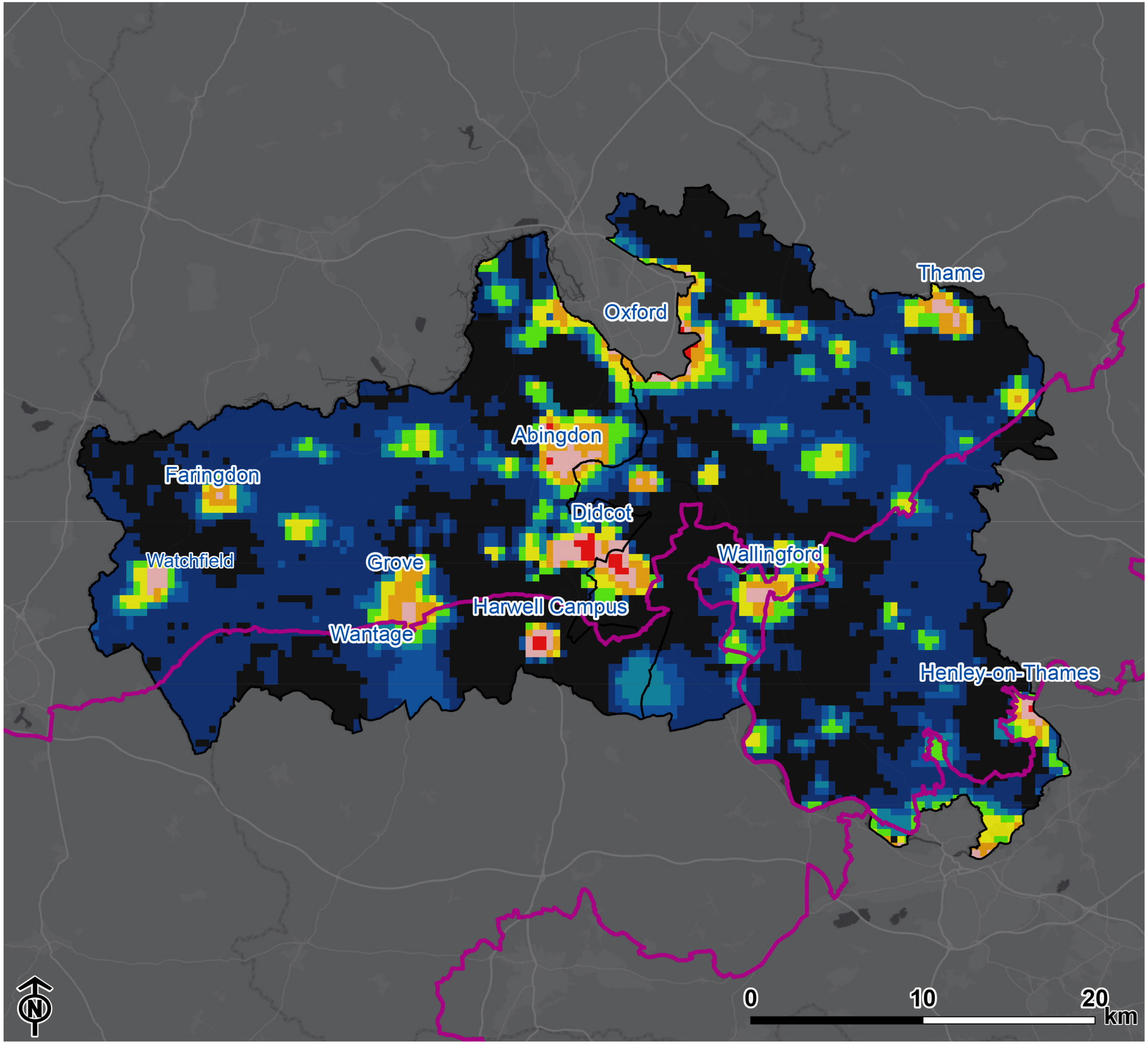
LUC

Figure 4.2: Dark Skies and Light Pollution



South Oxfordshire and Vale of White Horse

National Landscape

Night Lights (NanoWatts / cm2 / sr)

- >32
- 16 - 32
- 8 - 16
- 4 - 8
- 2 - 4
- 1 - 2
- 0.5 - 1
- 0.25 - 0.5
- < 0.25 (highest 50%)
- < 0.25 (lowest 50%)

Brightest

Darkest

Map scale 1:325,000 @ A4

Chapter 5

Headline figures and statistics

5.1 Using GIS (ESRI's Spatial Analyst extension), quantitative analysis has been undertaken to explore the dark skies data in more details. This section presents the findings of this analysis. The following areas were analysed:

- All South Oxfordshire and Vale of White Horse
- South Oxfordshire and Vale of White Horse separately to highlight trends that may be specific to each district.
- National Landscapes.

5.2 The following graph shows the breakdown of land coverage across All South Oxfordshire and Vale of White Horse into the ten colour bands of brightness values. The majority of the study area is within the darkest category (74.6% in colour band 1, which includes two sub-categories as shown in Table 4 a), and there are no band 9 (brightest) pixels within the area. Only 0.3% of the area falls within band 8 (16-32 nw/cm2/sr).

The same category/colour bands as the 2016 national map have been used for this assessment (with the addition of a subdivision within Band 1). As per the note in Chapter 4, the data values are not directly comparable to the national 2016 map. This means that significantly more area is shown as being in the darkest category than in 2016. Whilst there may be some exceptions, this should not be interpreted as an overall reduction in light pollution over this time period.

Figure 5.1: Percentage of South and Vale falling into each brightness category

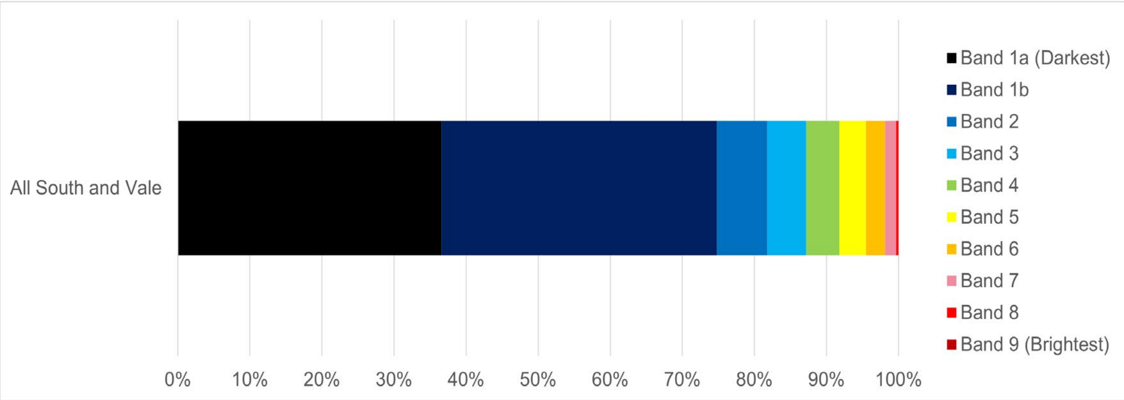


Table 5b: Area and percentage of South Oxfordshire and Vale of White Horse in each brightness category

Colour band	Area (square kilometre)	% of total area
Colour band 1a (Darkest)	459.20	36.53
Colour band 1b	479.52	38.14
Colour band 2	87.68	6.97
Colour band 3	68.00	5.41
Colour band 4	57.60	4.58
Colour band 5	46.24	3.68
Colour band 6	33.44	2.66
Colour band 7	19.36	1.54
Colour band 8	4.00	0.32
Colour band 9 (Brightest)	0	0

5.3 The following figure and table show the percentage of land and land area (kilometres squared (km^2)) falling into each of the colour bands for South Oxfordshire and Vale of White Horse Local Authority boundaries. Both local authorities have a similar profile across the different brightness categories, with South Oxfordshire having a slightly higher percentage of land falling within colour bands 1 (including 1a and 1b), 2 and 3 which are associated with darker pixels. South Oxfordshire also has a higher percentage of land falling within the top 50% of the darkest colour band (category 1a) compared to band 1b. Vale of White Horse has a higher proportion of land falling in band 1b than 1a.

Figure 5.2: Percentage of land falling into each brightness category per local authority

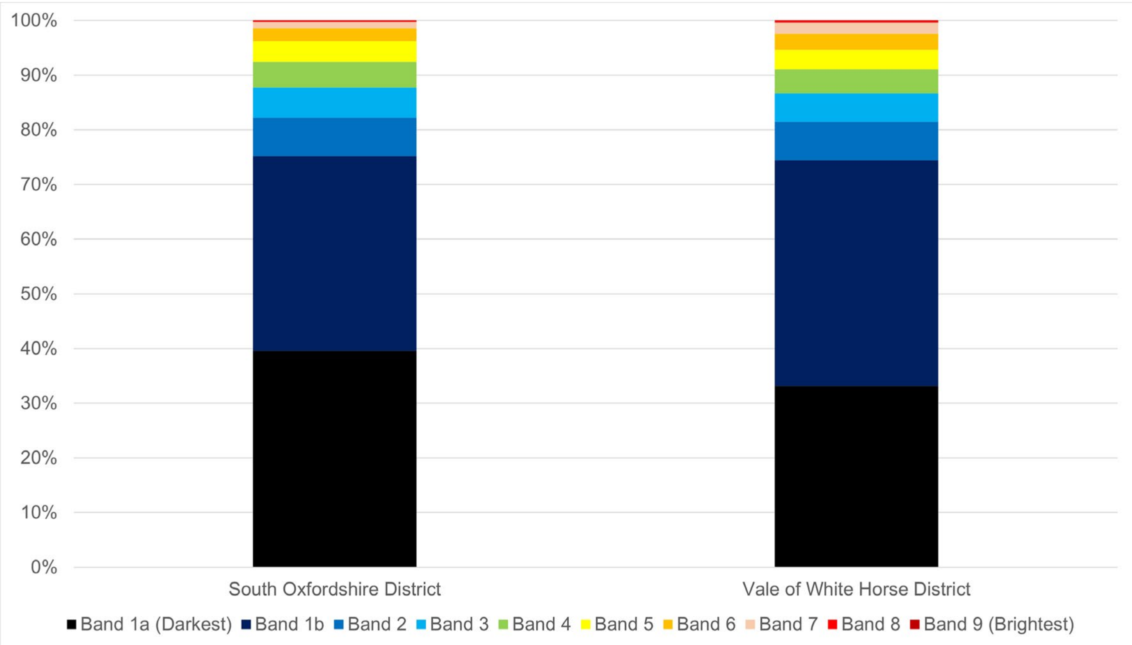


Table 5b: Percentage of each local authority falling into each brightness category

Colour band	South Oxfordshire %	Vale of White Horse %
Colour band 1a (Darkest)	39.5	33.0
Colour band 1b	35.5	41.2
Colour band 2	7.0	6.9
Colour band 3	5.6	5.2
Colour band 4	4.7	4.4
Colour band 5	3.8	3.5
Colour band 6	2.4	3.0
Colour band 7	1.1	2.0
Colour band 8	0.3	0.4
Colour band 9 (Brightest)	0	0

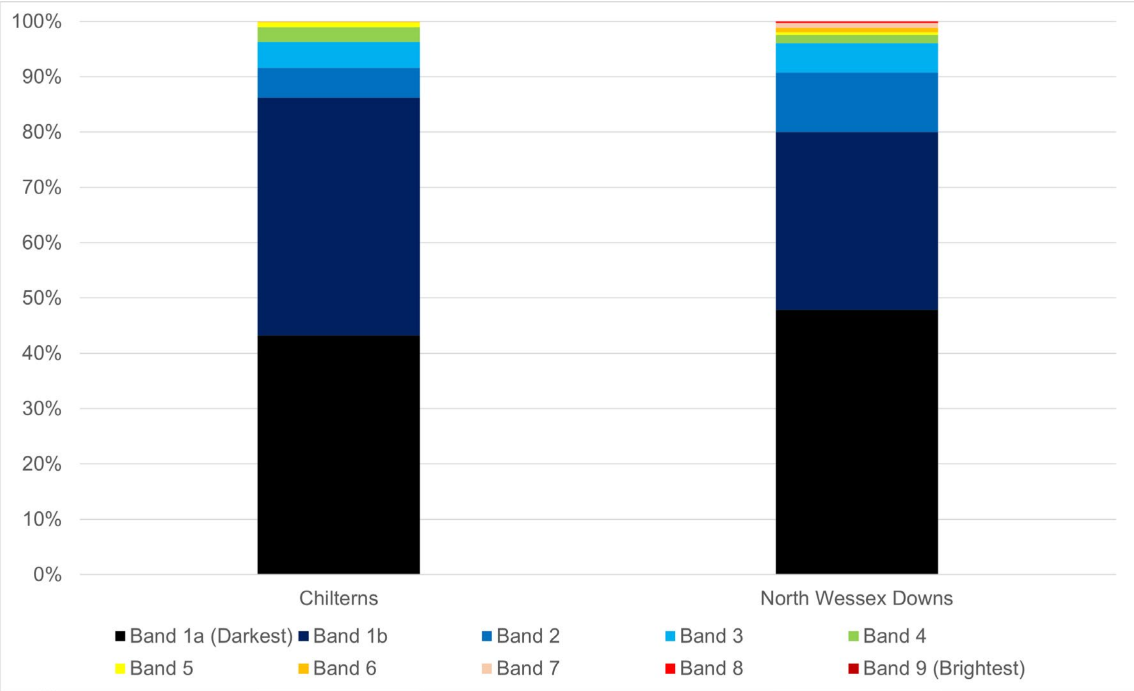
5.4 **Table 5c** shows the maximum and average (mean) brightness values for each local authority. South Oxfordshire has a slightly darker average brightness value than Vale of White Horse, with both authorities' average values corresponding to the colour bands 2 and 3, which represent very dark pixels. The brightest value in both South Oxfordshire and Vale of White Horse is found in Didcot / Milton (Vale of White Horse only). In South Oxfordshire there is another area of high brightness values located where the local authority boundary stops south of Oxford, as well as in Wallingford, Henley-on-Thames, Thame and the border with Reading. High brightness values in Vale of White Horse are observed in Abingdon-on-Thames, Harwell Campus, Faringdon, Watchfield, Wantage and Grove. The data is shown alongside the local authority and National Landscapes boundaries in **Figure 4 2**.

Table 5c: Comparison of maximum and average brightness values by local authority (NanoWatts/cm2/sr)

Local Authority	Maximum brightness value	Average brightness value (mean)
Vale of White Horse	22.70	0.53
South Oxfordshire	29.34	0.42

5.5 **Figure 5.3** shows that the two National Landscapes in the South Oxfordshire and Vale of White Horse study area experience little light pollution, with 91.7% of Chilterns and 90.1% of North Wessex Downs falling within the darkest categories (colour bands 1a, 1b and 2). North Wessex Downs has a higher percentage of land falling within the darkest colour band (category 1a). The Chilterns National Landscape has 1% of its land area within the brightest bands 5-7, with its brightest pixel being in band 7. North Wessex Downs National Landscape has a higher percentage of its area (2.4%) within the brightest four bands 5 to 8.

Figure 5.3: Percentage of each National Landscape falling into each brightness category



5.6 **Appendix E** contains a full breakdown of the proportion of each National Landscape in each brightness category, both as a percentage of the total National Landscape area and in square kilometres. The National Landscape boundaries are shown against the dark skies data in **Figure 4.2**.

Chapter 6

Identifying Environmental Zones

What does the guidance say?

6.1 Current CNEA legislation recognises light pollution as a statutory nuisance, but it does not explain how to control light pollution. This can be found in the following National and International bodies for lighting guidance: The Commission Internationale de l'Eclairage (International Commission on Illumination), (CIE), the Society of Light & Lighting (SLL), and the Institute of Lighting Professionals (ILP).

6.2 As the above guidance documents all apply a common Environmental Zoning system and provide associated light level limitations, they enable a quantifiable assessment of light pollution and the ability to apply, where necessary, exterior lighting control measures.

6.3 The Environmental Zoning system is summarised in **Table 6a**.

Table 6a: The Environmental Zoning system (reproduced from ILP GN01/21)

Zone	Surrounding	Lighting environment	Examples
E0	Protected	Dark (Sky Quality Metre 20.5+)	Astronomical Observable dark skies, UNESCO starlight reserves, IDA dark sky places.

Zone	Surrounding	Lighting environment	Examples
E1	Natural	Dark (Sky Quality Metre 20 to 20.5)	Relatively uninhabited rural areas, National Parks, National Landscapes, IDA buffer zones etc.
E2	Rural	Low district brightness (Sky Quality Metre ~15 to 20)	Sparsely inhabited rural areas, village or relatively dark outer suburban locations.
E3	Suburban	Medium district brightness	Well inhabited rural and urban settlements, small town centres of suburban locations.
E4	Urban	High district brightness	Town/City centres with high levels of night-time activity.

Identifying Environmental Zones for South Oxfordshire and Vale of White Horse

6.4 The updated map of dark skies and light pollution (**Figure 4.2**) uses satellite data (based on a 400 m^2 pixels), to identify radiance levels from existing night-time lighting which is then translated into a map showing nanowatts per square centimetre steradian as described in **Chapter 4**.

6.5 The satellite data was classified into ten separate bands (the nine colour bands used in the national map with further sub-division within band 1) representing darkest to brightest pixels, as detailed in **Chapter 4**. Hoare Lea have used their professional judgment to assign each brightness band from the dark skies map into Environmental Zones E1 to E4 as shown in **Table 6b**.

6.6 The resulting zones in the two districts are presented in **Figure 6.1**.

Environmental Zones (EZ) are defined in CIE 150 and ILP GN01/21 guidance, and these documents provide a descriptive definition of each zone. It is important to state that CIE 150 puts no numerical values on a particular EZ. GN01/21 references Sky Quality Meter (SQM) values for Zones E0 to E2, however SQM readings are difficult to capture. Therefore the geographical location descriptive 'Examples' in column 4 **Table 6a** (Dark Skies places (E0) through to Town/City Centres (E4)) provide a better understanding of an existing Environmental Zone based on human activity in an area.

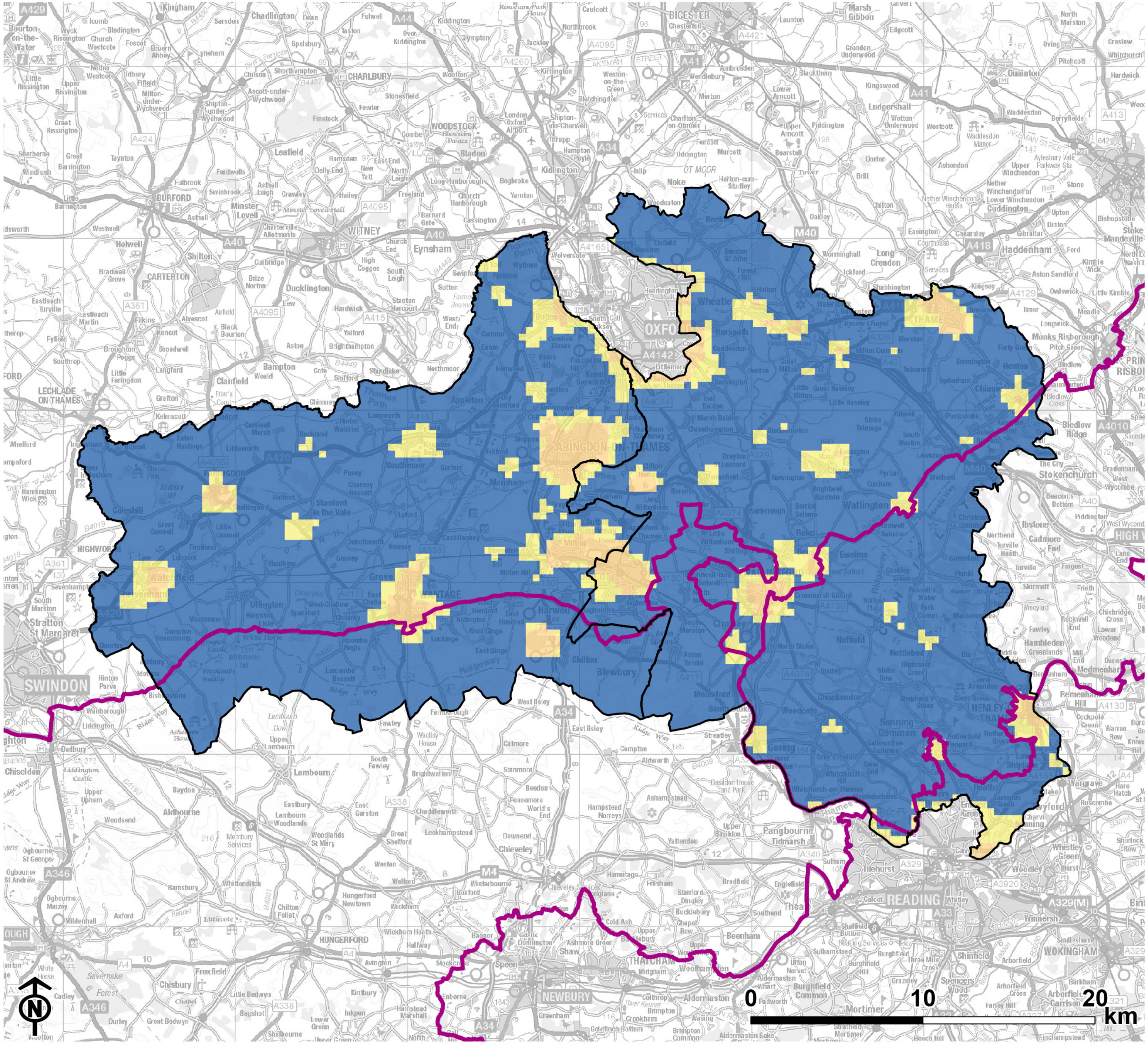
Important note: It must be noted that no E0 zones have been identified using the approach detailed in this assessment. However, the approach used to map EZ in the North Wessex Downs Guide to Good External Lighting **[See reference** 55**]** differs and has identified E0 areas around the darkest areas of the 2016 CPRE Night Blight map **[See reference** 56**]**. These E0 areas are located within the E1 zones of this report. E0 zones tend to be associated with areas that have achieved Dark Skies accreditation from the IDA, but the ILP's definition of the EZ states that a more stringent zone classification may be applied to protect specific areas. Therefore, there is flexibility to increase the EZ in a protected designation like a National Landscape, which is what was done in the North Wessex Downs Guide to Good External Lighting.

Table 6b: Assigning Environmental Zones in South Oxfordshire and Vale of White Horse using the 2022 dark skies map

Colour band	Brightness values (in nw/cm2/sr)	Environmental Zone
Colour band 1a (Darkest)	<0.25 (lowest 50% values)	E1
Colour band 1b	<0.25 (highest 50% values)	E1
Colour band 2	0.25-0.5	E1
Colour band 3	0.5-1	E1
Colour band 4	1-2	E2
Colour band 5	2-4	E2
Colour band 6	4-8	E3
Colour band 7	8-16	E3
Colour band 8	16-32	E3
Colour band 9 (Brightest)	>32	E4

Dark Skies Assessment
South Oxfordshire and Vale of White Horse Councils

Figure 6.1: Environmental Zones



South Oxfordshire and Vale of White Horse

National Landscape

Environmental Zone

Natural dark zone (E1)

Rural low district brightness zone (E2)

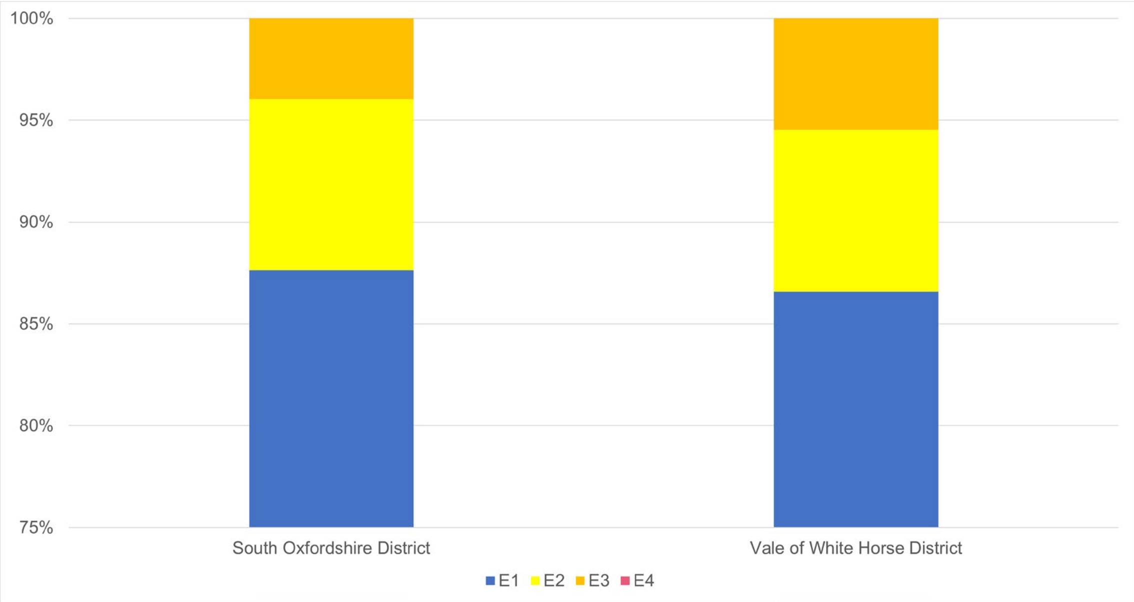
Suburban medium district brightness zone (E3)

Urban high district brightness zone (E4)

Map scale 1:325,000 @ A4

6.7 The following graph shows the proportion of South Oxfordshire and Vale of White Horse that fall into each Environmental Zone. Most of the districts' area is within Environmental Zone E1 (87.7% in South Oxfordshire and 86.3% in Vale of White Horse). 8.4% of South Oxfordshire falls in E2 and 4% in E3. There is a similar trend in Vale of White Horse, with 7.9% in E2 and 5.4% in E3. There is no E4 in either of the district.

Figure 6.2: Percentage of South Oxfordshire and Vale of White Horse falling into each Environmental Zone



6.8 Environmental Zones cannot be defined solely based on the dark skies map produced using satellite data. The reason being each pixel of the satellite data captures an area of 400 square metres. This method gives a general overview of the amount of upward light across an area, from which we can infer an Environmental Lighting Zone. However, the map does not provide enough detail to differentiate specific lighting activity within the pixel.

6.9 The limitations of the pixel resolution are more evident when viewing peripheries between developed and undeveloped areas on the map. **Chapter 4** sets out satellite data limitations**. Figure 6.3** provides an example of the limitations of the satellite data when categorising Environmental Zones. It shows surrounding rural areas in the south-east of Abingdon-on-Thames, such as green fields, being categorised in E2 and E3 even though there is no artificial light present in certain parts of this area (it is clear that unlit fields are present).

6.10 As explained previously, the dark skies map has its limitations with regards to the specifics of the current areas. Understanding the current artificial lighting in a certain area is a way of clarifying Environmental Zone. Therefore it may be necessary to carry out one or both of the following exercises in order to get a more detailed understanding of the Environment Zone a particular site falls within:

- Desktop site survey using online maps
- Physical baseline on-site survey

6.11 Desktop site survey uses professional judgment to ascertain the Environmental Zone using online data. The downside to using online data is that it is not always an accurate reflection of the present condition because online maps can be out of date.

6.12 A physical baseline on-site survey consists of the lighting professional determining the appropriate number and location of sample readings to be taken, taking into account the light sensitive receptors in and around the proposed development area. Four vertical readings at 1.5 metre above ground oriented towards the proposed site, and at 90, 180 and 270° from this, as well as horizontal (ground) measurements should be recorded at each sample location. An appropriately high quality light metre (V-Landor and Cosine Corrected) should be used such as a Minolta T10a.

6.13 In order to identify sensitive locations, it may be advisable that the lighting professional should liaise with an ecologist.

6.14 ILP PLG04 provides a more detailed understanding of desktop and on-site survey approaches

Accessing the map

6.15 An online map **[See reference** 57**]** was created to display the dark skies and Environmental Zones maps.

6.16 The interactive maps allow users to explore their area of interest in more detail, particularly where it may be obscured or hard to discern at the scale of the maps contained within this report. The map also includes contextual boundaries such as Conservation Areas and nature conservation designations. It also displays the parishes in both districts that electively have no street lighting (also included in **Appendix F**).

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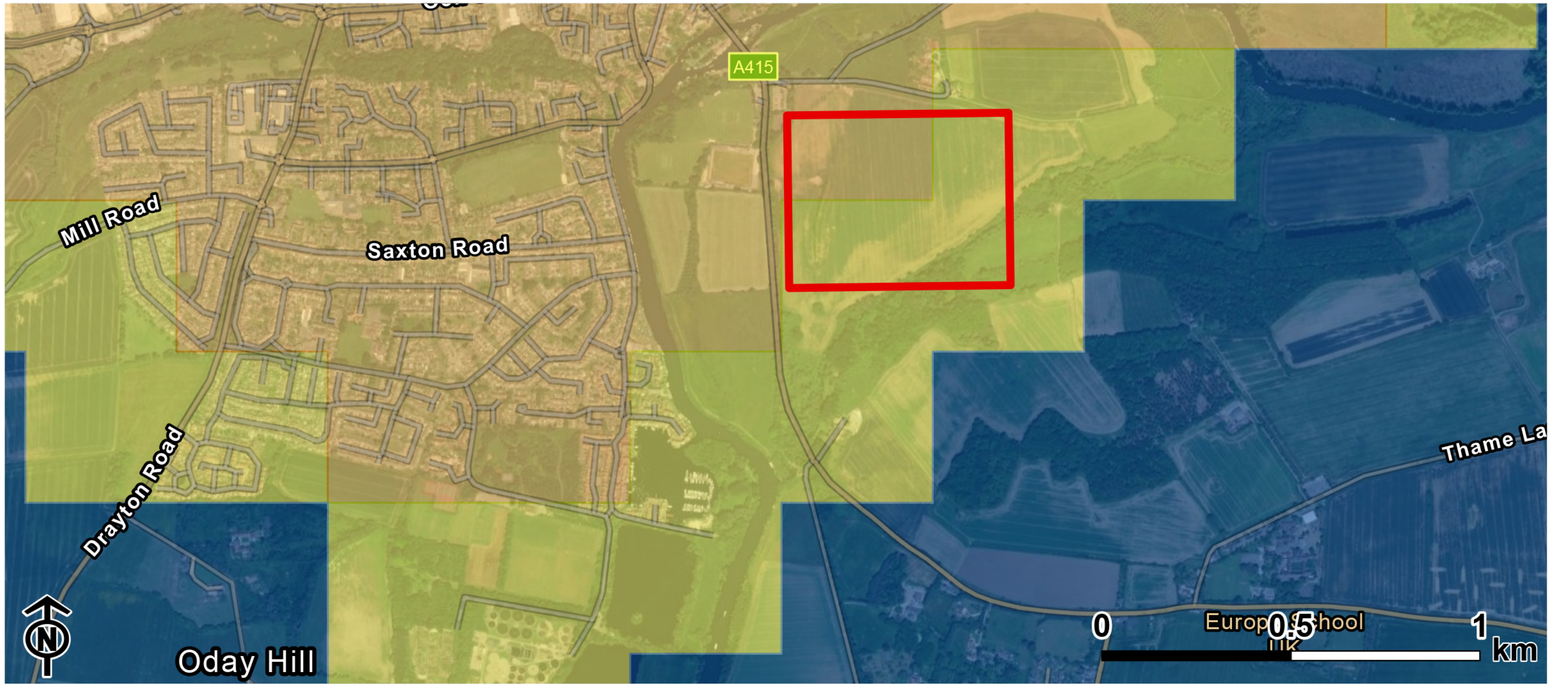
Figure 6.3: Limitations of using the satellite data to define Environmental Zones



Green field near Abingdon-on-Thames

Environmental Zone

- Natural dark zone (E1)
- Rural low district brightness zone (E2)
- Suburban medium district brightness zone (E3)

Map scale 1:20,000 @ A4

Maxar, Microsoft, Esri UK, Esri, HERE, Garmin, Foursquare, GeoTechnologies, Inc, METI/NASA, USGS, LUC, Hoare Lea

Appendix A

Light and Obtrusive Light Standards and Guidance Documents

A.1 Below are just a few examples of documents that may be relevant when designing lights for the external environment. The important point to note is that a suitably qualified lighting designer should always be consulted to ensure the right standards and guidance are referenced.

Please note that not all guidance listed in the next sections are freely accessible.

British Standards

- BS 5489-1:2020 Code of practice for the design of road lighting – Part 1 Lighting of roads and public amenity areas
  - This document is available online through the following link: https://knowledge.bsigroup.com/products/design-of-road-lighting-lighting-of-roads-and-public-amenity-areas-code-of-practice?version=tracked
- BS EN 13201-2:2015 Road lighting; Part 2: Performance requirements
  - This document is available online through the following link: https://www.mklights.com/data/upload/ueditor/20210904/613329b522bf2.pdf
- BS EN 13201-3:2015 Road lighting; Part 3: Calculation of performance
  - This document is available online through the following link: https://knowledge.bsigroup.com/products/road-lighting-calculation-of-performance-1?version=tracked

- BS EN 13201-4:2015 Road lighting; Part 4: Methods of measuring lighting performance
  - This document is available online through the following link: https://knowledge.bsigroup.com/products/road-lighting-methods-of-measuring-lighting-performance-1?version=standard&tab=preview
- BS EN 12193:2018 Light and lighting; Sports lighting
  - This document is available online through the following link: https://www.normadoc.com/english/bs-en-12193-2018.html
- PD CEN TR 13201-1:2014 Road lighting; Guidelines on selection of lighting classes
  - This document is available online through the following link: https://knowledge.bsigroup.com/products/road-lighting-guidelines-on-selection-of-lighting-classes?version=standard
- BS EN 12464-2:2014 Light and lighting; Lighting of work places; Part 2 Outdoor work places
  - This document is available online through the following link: https://knowledge.bsigroup.com/products/light-and-lighting-lighting-of-work-places-outdoor-work-places?version=standard
- BS EN 1838:2013 Lighting Applications - Emergency Lighting
  - This document is available online through the following link: https://knowledge.bsigroup.com/products/lighting-applications-emergency-lighting-1?version=standard
- BS 5266-1:2016 Emergency lighting - Part 1 Code of Practice for the Emergency Lighting of Premises
  - This document is available online through the following link: https://knowledge.bsigroup.com/products/emergency-lighting-code-of-practice-for-the-emergency-lighting-of-premises?version=tracked

CIE Publications

- 001 Guidelines for minimizing urban skyglow near astronomical observatories
  - This document is available online through the following link: https://cie.co.at/publications/guidelines-minimizing-urban-sky-glow-near-astronomical-observatories-joint-publication
- CIE 094-1993 Guide for flood lighting
  - This document is available online through the following link: https://cie.co.at/publications/guide-floodlighting
- CIE 112-1994 Glare evaluation system for use within outdoor sport and area lighting
  - This document is available online through the following link: https://cie.co.at/publications/glare-evaluation-system-use-within-outdoor-sport-and-area-lighting
- CIE 115:2010 Lighting of roads for motor and pedestrian traffic
  - This document is available online through the following link: https://cie.co.at/publications/lighting-roads-motor-and-pedestrian-traffic-2nd-edition
- CIE 126:1997 Guidelines for Minimising Sky Glow
  - This document is available online through the following link: https://cie.co.at/publications/guidelines-minimizing-sky-glow#:~:text=The%20report%20discusses%20briefly%20the,be%20regarded%20as%20limiting%20values .
- CIE 129:1998 Guide for lighting exterior working areas
  - This document is available online through the following link: https://cie.co.at/publications/guide-lighting-exterior-work-areas
- CIE 136:2000 Guide to the lighting of urban areas
  - This document is available online through the following link: https://cie.co.at/publications/guide-lighting-urban-areas

- CIE 150:2017 Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations
  - This document is available online through the following link: https://cie.co.at/publications/guide-limitation-effects-obtrusive-light-outdoor-lighting-installations-2nd-edition
- CIE 169:2005 Practical design guidelines for the lighting of sport events for colour ILP publications
  - This document is available online through the following link: https://cie.co.at/publications/practical-design-guidelines-lighting-sport-events-colour

ILP Publications

- PLG 04 Guidance on undertaking environmental lighting impact assessments
  - This document is available online through the following link: https://theilp.org.uk/publication/plg04-guidance-on-undertaking-environmental-lighting-impact-assessments/
- PLG 05 The brightness of illuminated advertisements
  - This document is available online through the following link: https://theilp.org.uk/publication/plg05-the-brightness-of-illuminated-advertisements/
- PLG 06 Guidance on seasonal decorations and lighting column attachments
  - This document is available online through the following link: https://theilp.org.uk/publication/plg06-guidance-on-installation-and-maintenance-of-seasonal-decorations-and-lighting-column-attachments/
- PLG 23 Lighting for Cycling Infrastructure
  - This document is available online through the following link: https://theilp.org.uk/publication/plg23-lighting-for-cycling-infrastructure/

- GN01/21 Guidance Notes for the Reduction of Obtrusive Light
  - This document is available online through the following link: https://theilp.org.uk/publication/guidance-note-1-for-the-reduction-of-obtrusive-light-2021/
- GN08/18 Bats and Artificial Lighting in the UK
  - This document is available online through the following link: https://cdn.bats.org.uk/uploads/pdf/Resources/ilp-guidance-note-8-bats-and-artificial-lighting-compressed.pdf?v=1542109349
- GN 09 Domestic Security Lighting: Getting it right!
  - This document is available online through the following link: https://theilp.org.uk/publication/guidance-note-9-domestic-exterior-lighting-getting-it-right/

SLL / CIBSE Publications

- LG 01: The industrial environment (2018)
  - This document is available online through the following link: https://www.cibse.org/knowledge-research/knowledge-portal/lighting-guide-01-the-industrial-environment-2018
- LG 04: Sports lighting (2023)
  - This document is available online through the following link: https://www.cibse.org/knowledge-research/knowledge-portal/lg4-sports-lighting-2023
- LG 06: The outdoor environment (2016)
  - This document is available online through the following link: https://www.cibse.org/knowledge-research/knowledge-portal/lighting-guide-06-the-exterior-environment-2016
- LG 21: Protecting the night-time environment (2021)

  - This document is available online through the following link: https://www.cibse.org/knowledge-research/knowledge-portal/lg21-protecting-the-night-time-environment

Other publications worth noting

- Dark Skies of the North Wessex Downs
  - This document is available online through the following link: https://www.northwessexdowns.org.uk/our-work/our-current-projects/dark-skies/
- All-Party Parliamentary Group (APPG) for Dark Skies: Ten Dark Sky policies for the government
  - This document is available online through the following link: https://appgdarkskies.co.uk/policy-plan
- South Downs National Park Authority Tranquillity Study
  - This document is available online through the following link: https://www.southdowns.gov.uk/wp-content/uploads/2017/03/13-04-17-South-Downs-National-Park-Tranquillity-Study.pdf
- Yorkshire Dales National Park External Lighting Master Plan
  - This document is available online through the following link: https://www.yorkshiredales.org.uk/park-authority/looking-after/dark-sky/good-lighting-advice/
- Other National Parks, local authorities bordering National Landscapes and national policy makers (APPG for Dark Skies) also offer recommendations and guidance to do with the reduction and control of light pollution.
  - This document is available online through the following link: https://appgdarkskies.co.uk/policy-plan

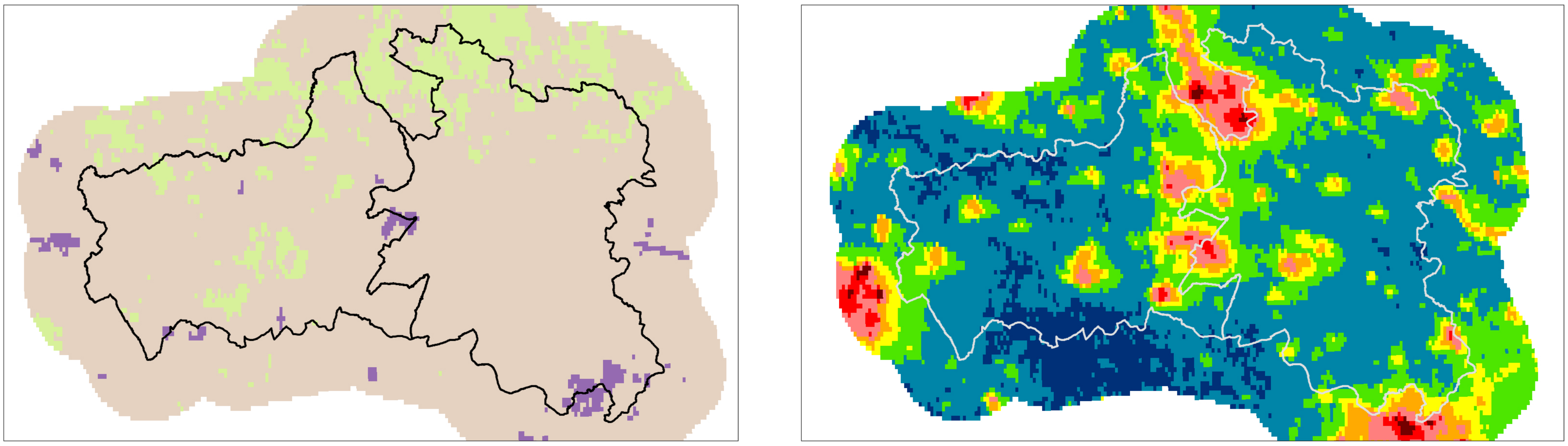
Appendix B

Cloud cover maps for month selection

B.1 Please note that these maps were created early in the project for decision making purposes, and have not been updated to reflect design choices made later.

B.2 August 2022 appears to be the month with the most cloud free days, however this month was removed from the analysis due to a satellite malfunction during this period which caused data quality issues.

2021-10



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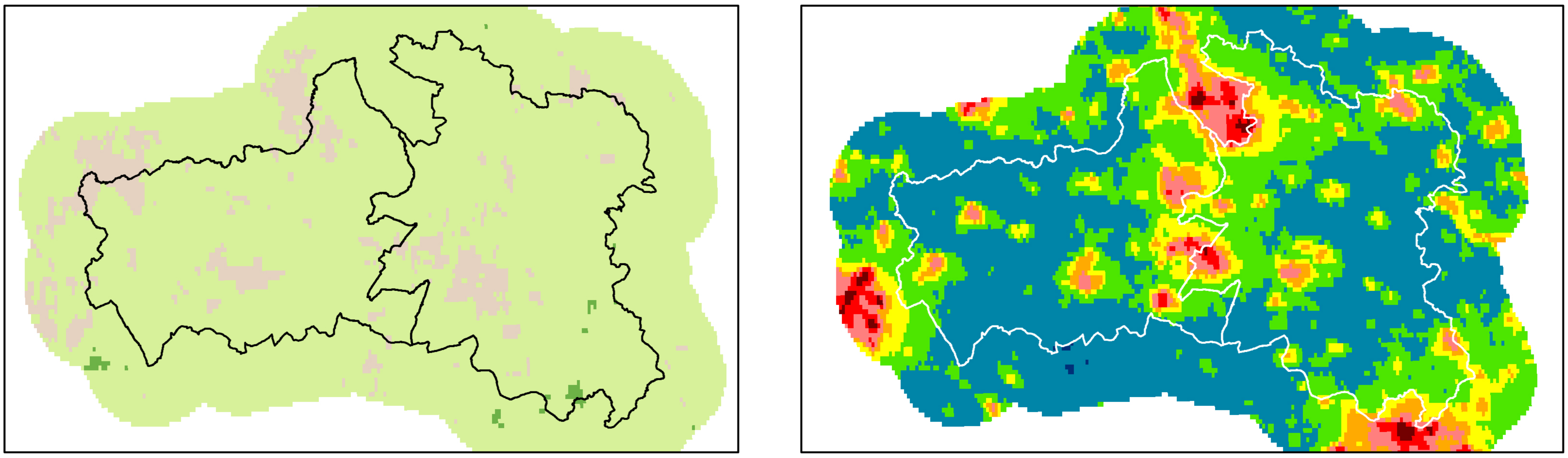

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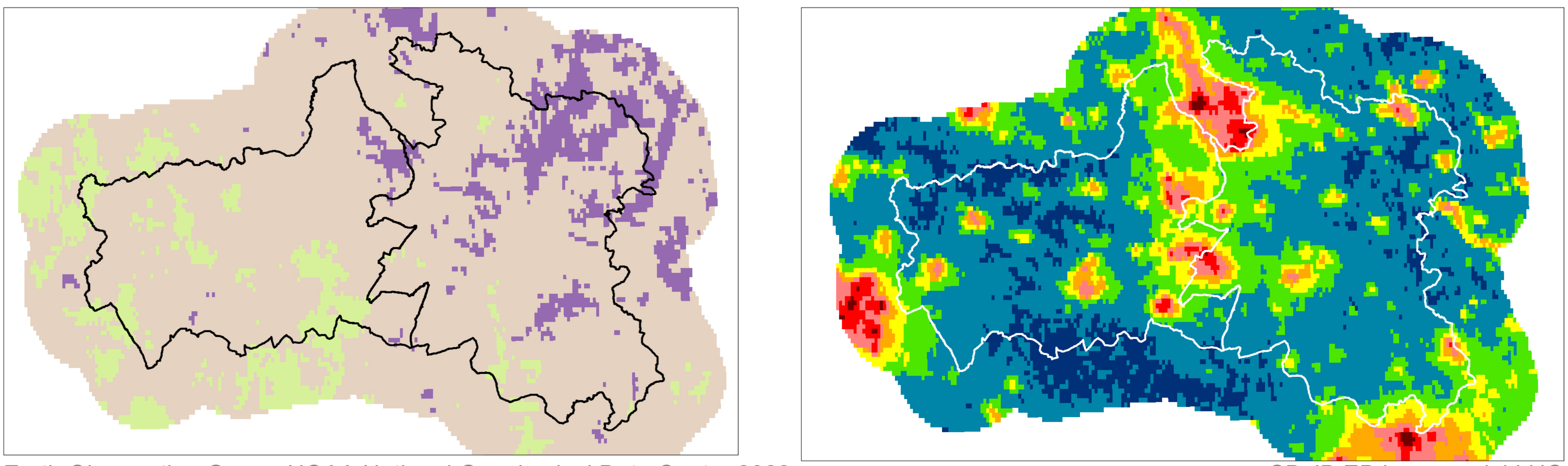


Earth Observation Group, NOAA National Geophysical Data Center 2022

CB:JB EB:bournazel_j LUC
12315_r1_DarkSkies_Data_Selection_2021_10_11_12 16/05/2023
Source: Visible Infrared Imaging Radiometer Suite, (VIIRS) Dat/Nigt Band (DNB), Earth Observation Group, NOAA National Geophysical Data Center, Colorado School of Mines

N 0 50 100 km

Map scale 1:565,000 @ A3

2021 quarter 4 cloud cover and radiance

Dark Skies Assessment
South Oxfordshire and Vale of White Horse

LUC

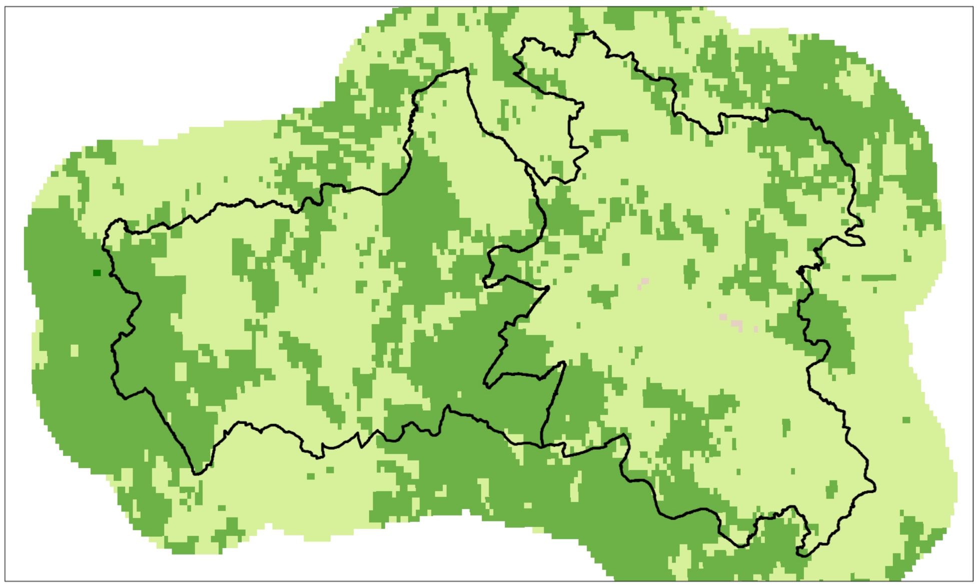
Cloud free days

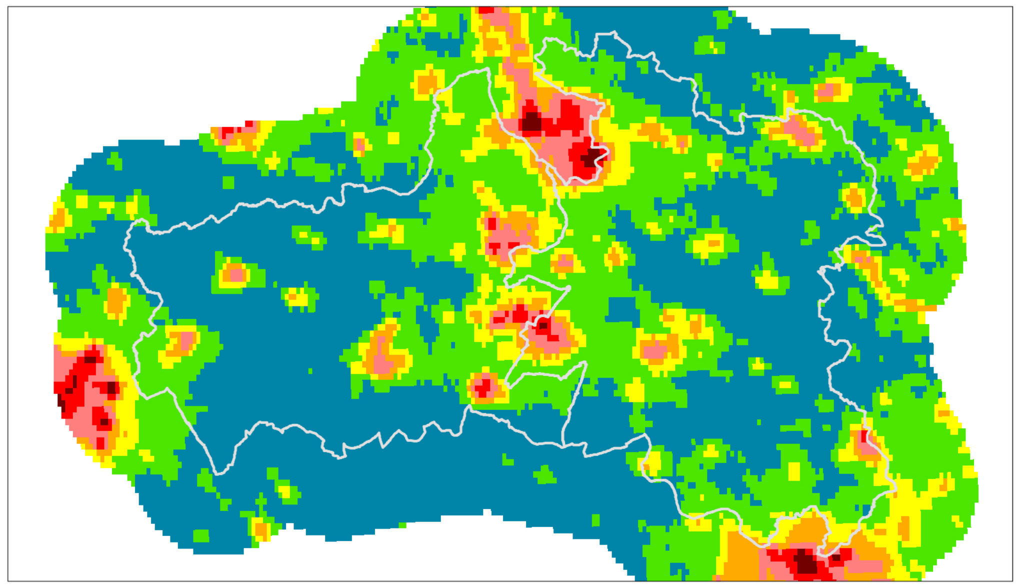
- 0
- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 +

Night lights (Nano Watts / cm2/ sr)

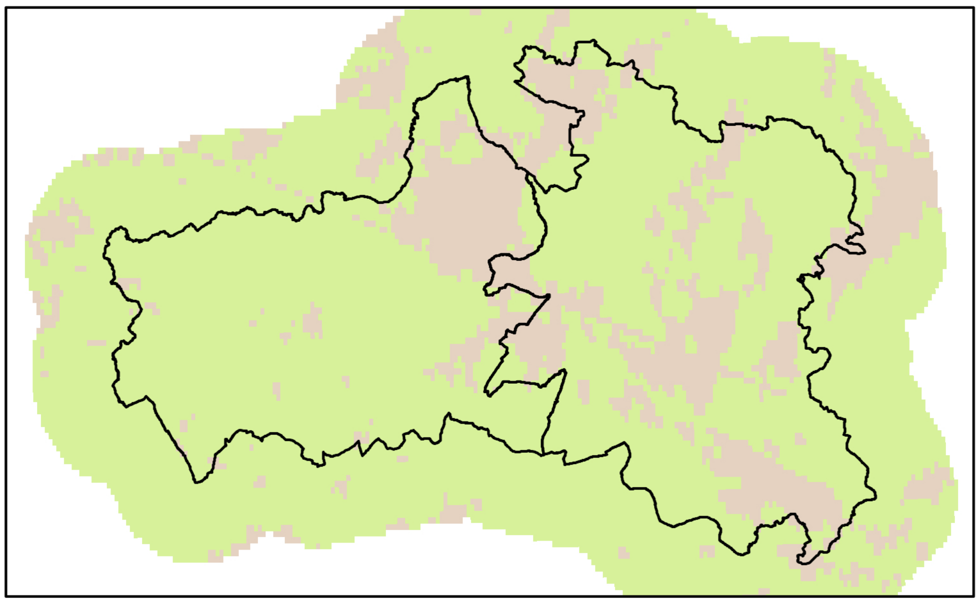
- <0.25 — Darkest
- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4 — Brighter
- 4 - 8
- 8 - 16
- 16 - 32
- >32 — Brightest

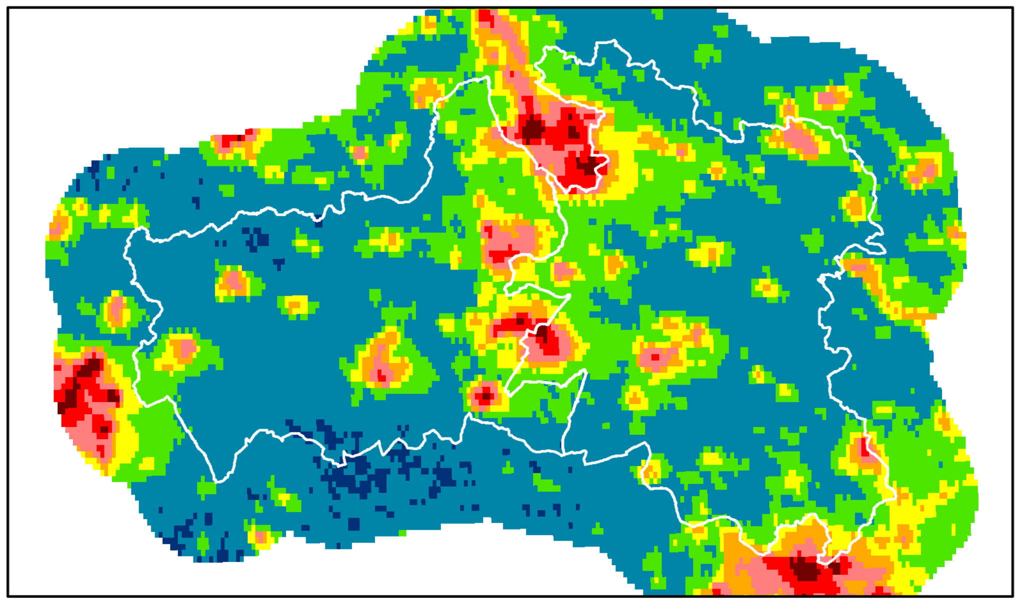
2022-01





2022-02





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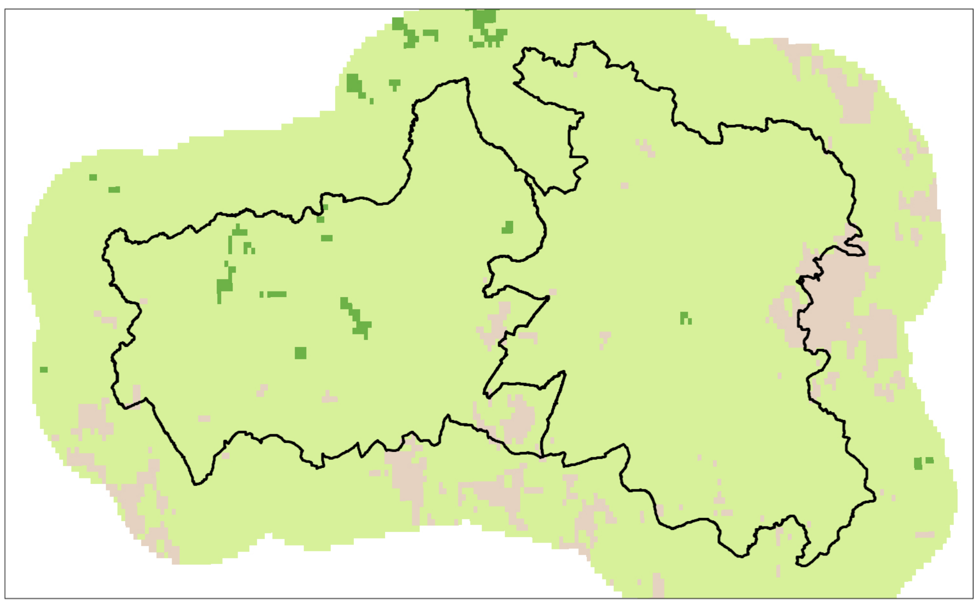
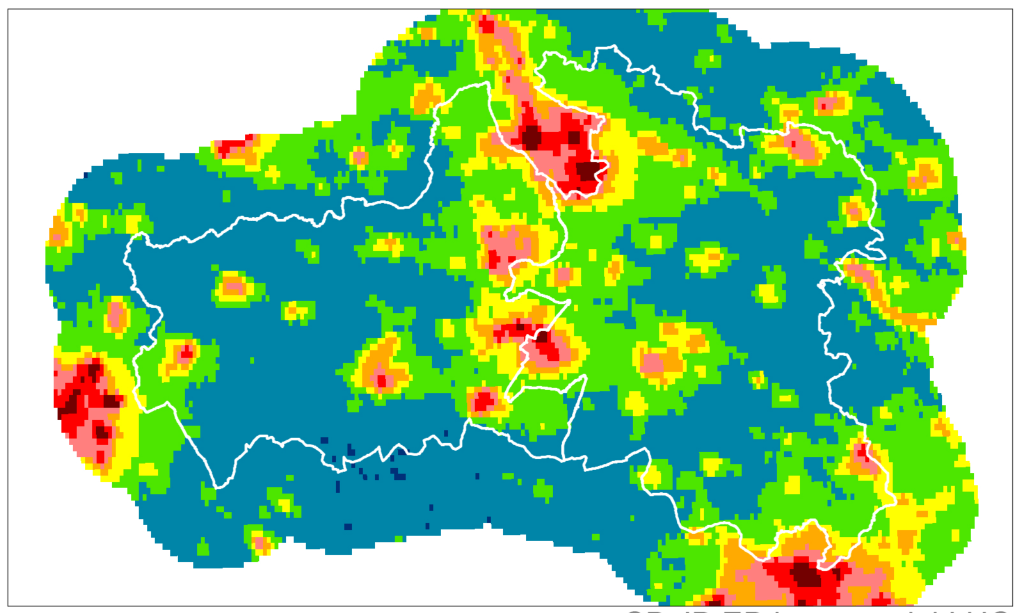




Earth Observation Group, NOAA National Geophysical Data Center 2022

CB:JB EB:bournazel_j LUC
12315_r1_DarkSkies_Data_Selection_2022_01_02_03 16/05/2023
Source: Visible Infrared Imaging Radiometer Suite, (VIIRS) Dat/Nigt Band (DNB), Earth Observation Group, NOAA National Geophysical Data Center, Colorado School of Mines

N 0 50 100 km

Map scale 1:565,000 @ A3

2022 quarter 1 cloud cover and radiance

Dark Skies Assessment
South Oxfordshire and Vale of White Horse

LUC

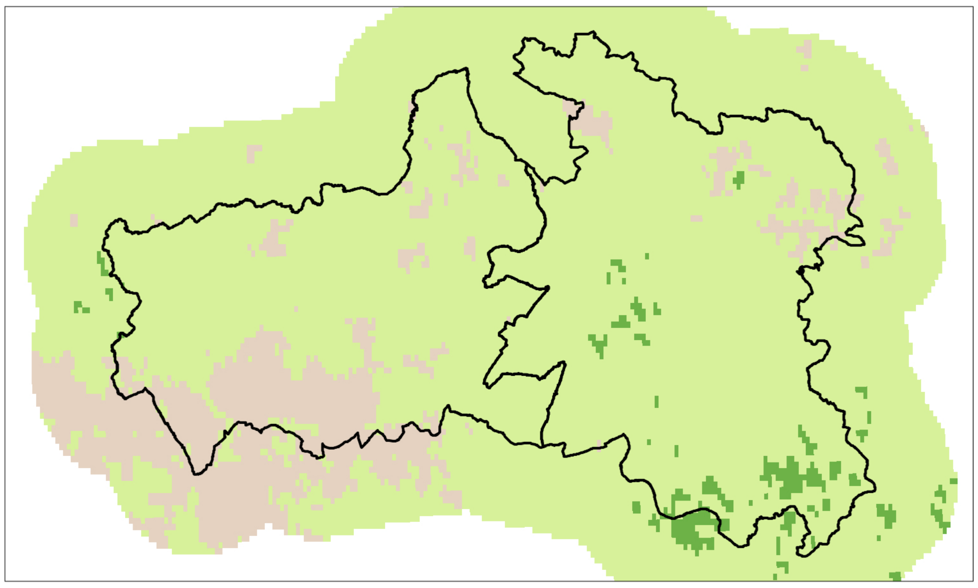
Cloud free days

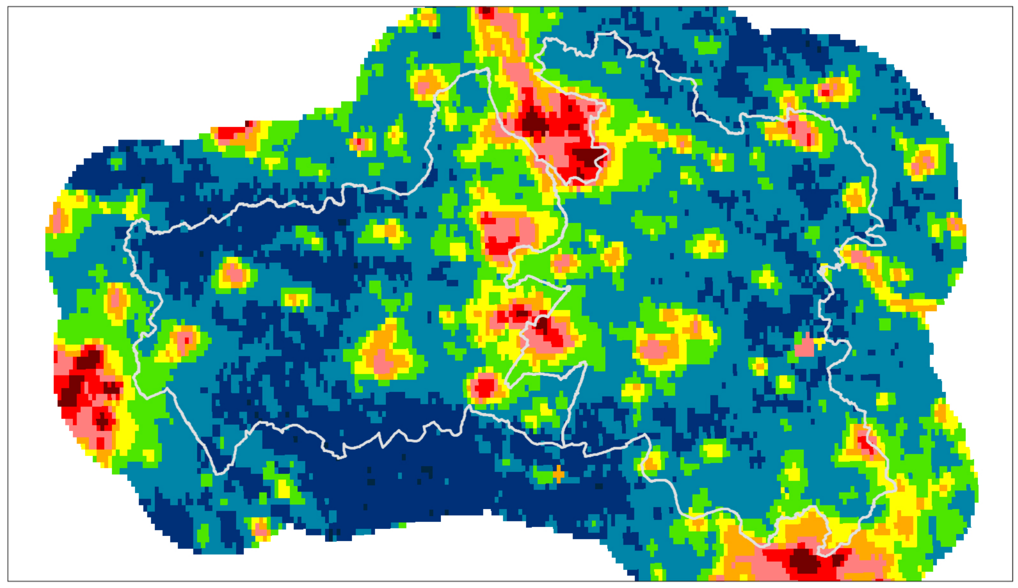
- 0
- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 +

Night lights (Nano Watts / cm2/ sr)

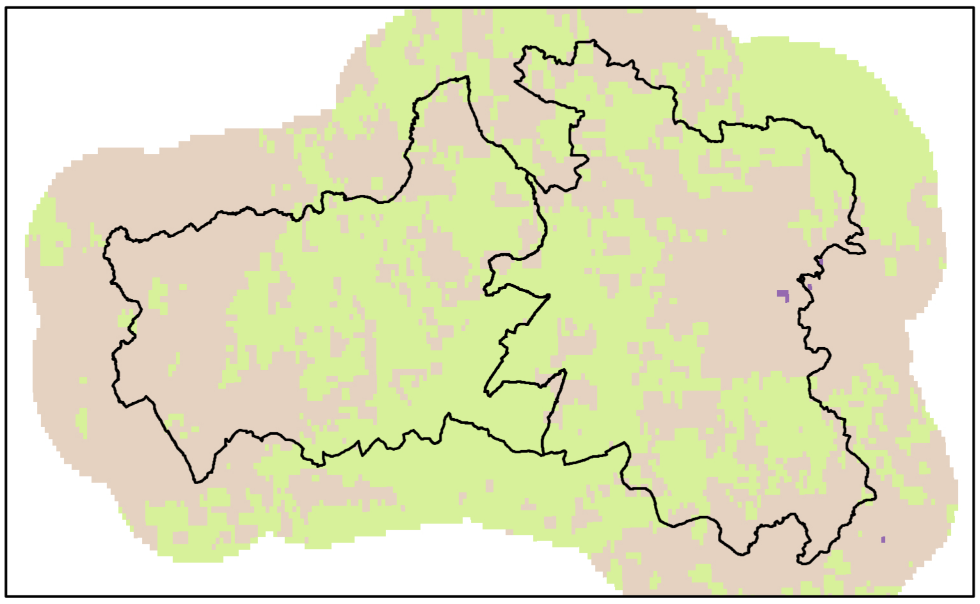
- <0.25 — Darkest
- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4 — Brighter
- 4 - 8
- 8 - 16
- 16 - 32
- >32 — Brightest

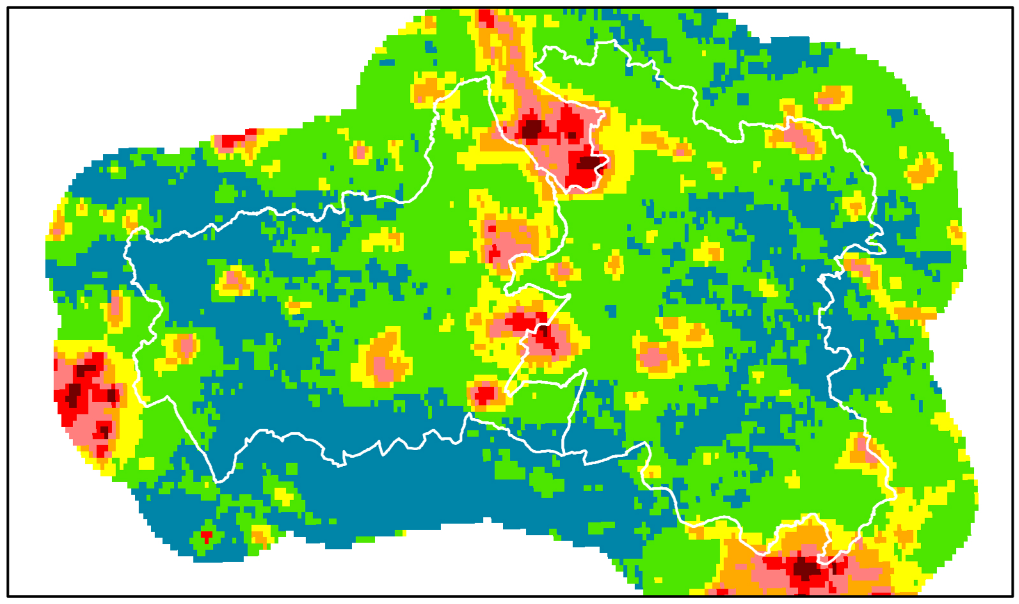
2022-04





2022-05





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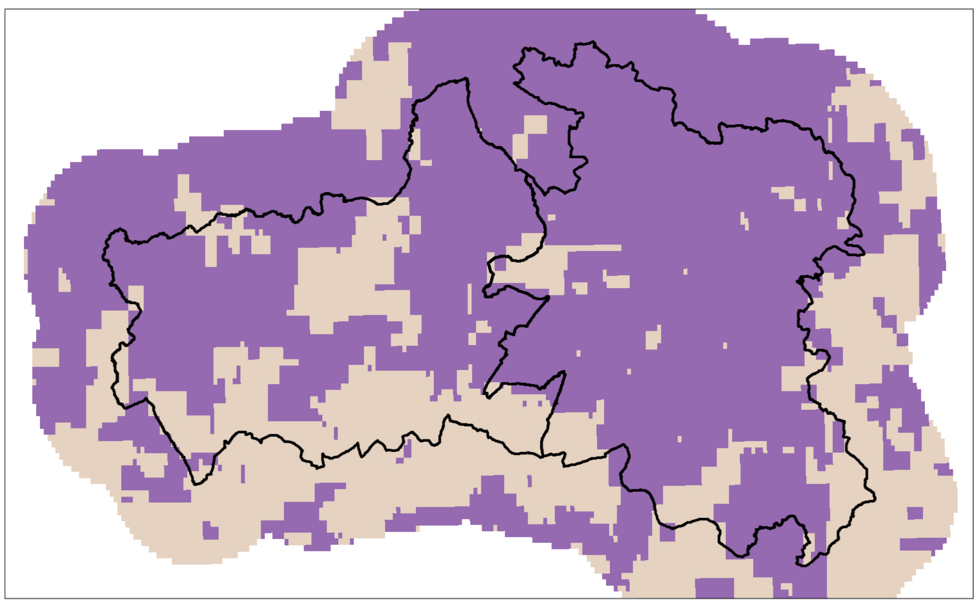
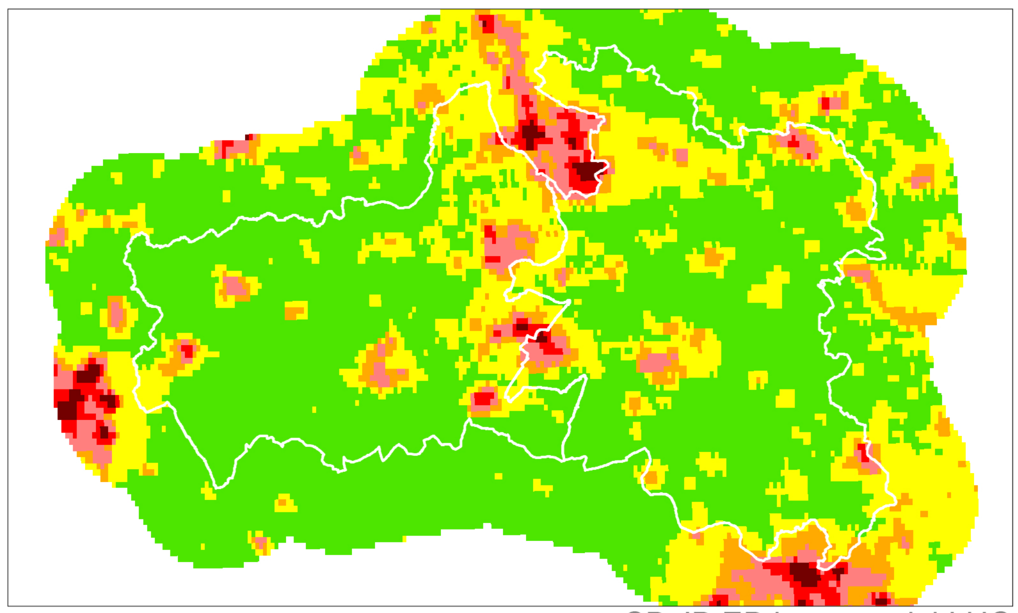




Earth Observation Group, NOAA National Geophysical Data Center 2022

CB:JB EB:bournazel_j LUC
12315_r1_DarkSkies_Data_Selection_2022_04_05_06 16/05/2023
Source: Visible Infrared Imaging Radiometer Suite, (VIIRS) Dat/Nigt Band (DNB), Earth Observation Group, NOAA National Geophysical Data Center, Colorado School of Mines

N 0 50 100 km

Map scale 1:565,000 @ A3

2022 quarter 2 cloud cover and radiance

Dark Skies Assessment
South Oxfordshire and Vale of White Horse

LUC

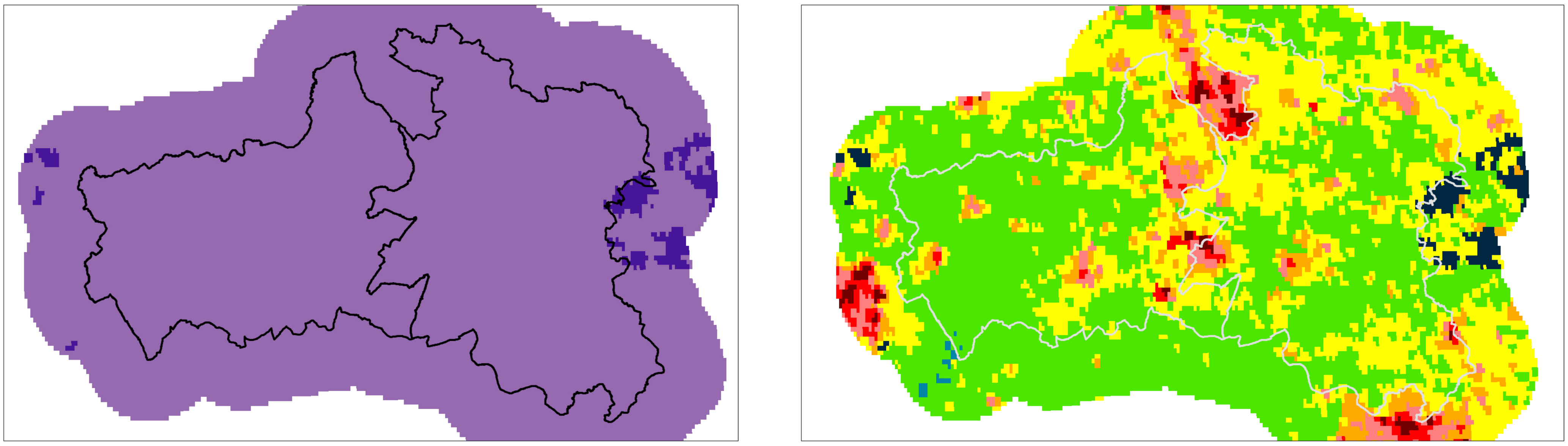
Cloud free days

- 0
- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 +

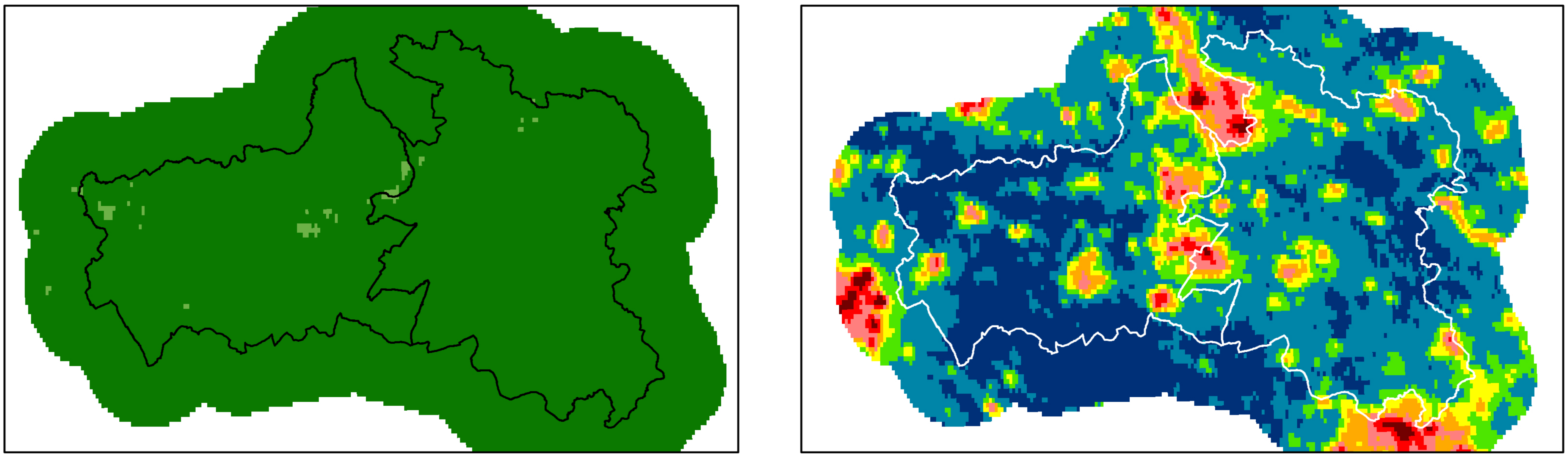
Night lights (Nano Watts / cm2/ sr)

- <0.25 — Darkest
- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4 — Brighter
- 4 - 8
- 8 - 16
- 16 - 32
- >32 — Brightest

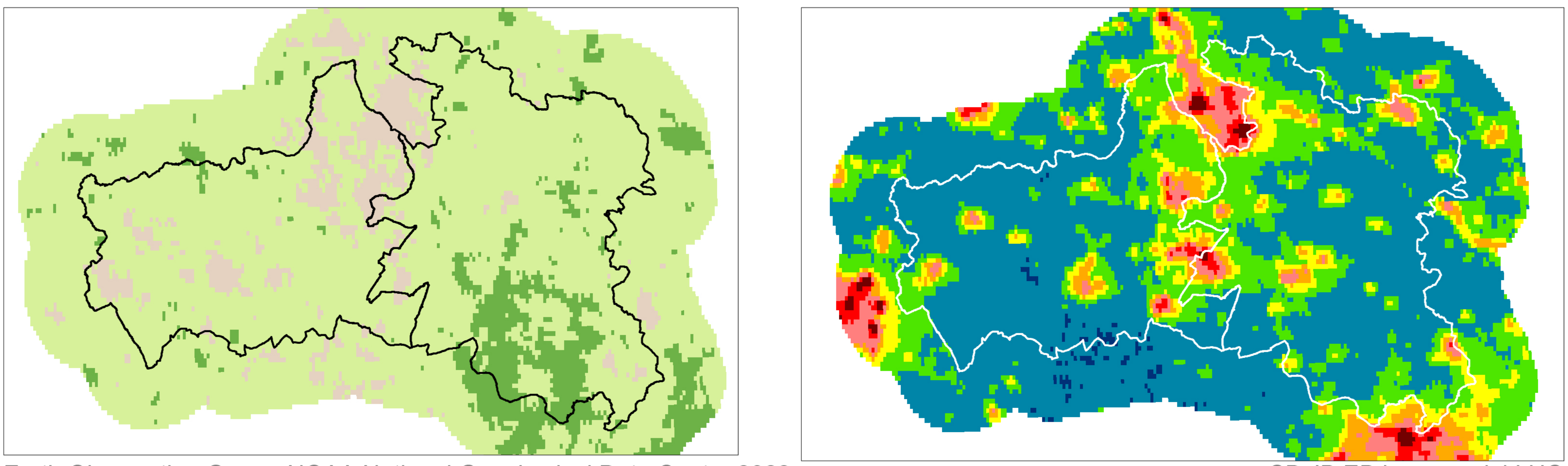
2022-07



2022-08



2022-09



Earth Observation Group, NOAA National Geophysical Data Center 2022

CB:JB EB:bournazel_j LUC
12315_r1_DarkSkies_Data_Selection_2022_07_08_09 16/05/2023
Source: Visible Infrared Imaging Radiometer Suite, (VIIRS) Dat/Nigt Band (DNB), Earth Observation Group, NOAA National Geophysical Data Center, Colorado School of Mines

N 0 50 100 km

Map scale 1:565,000 @ A3

2022 quarter 3 cloud cover and radiance

Dark Skies Assessment
South Oxfordshire and Vale of White Horse

LUC

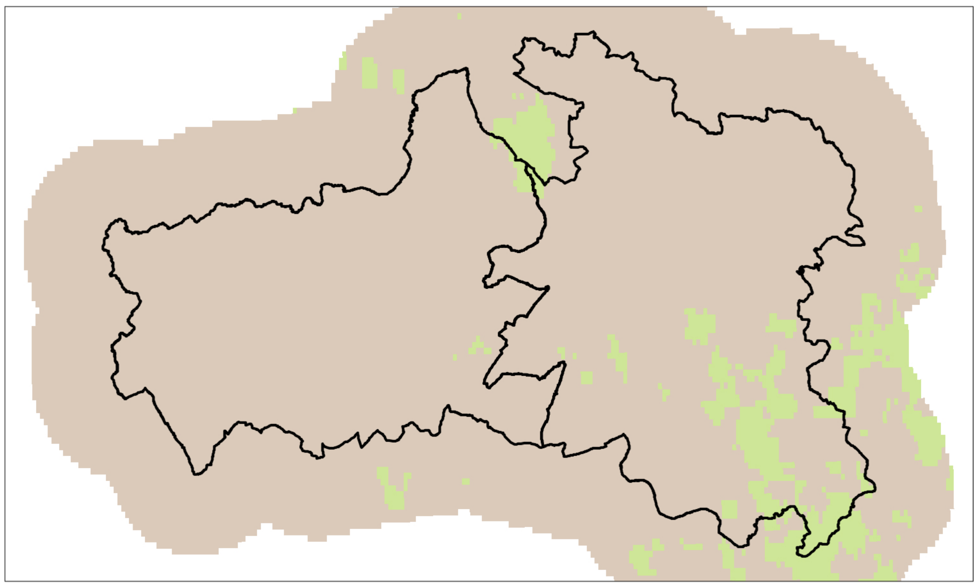
Cloud free days

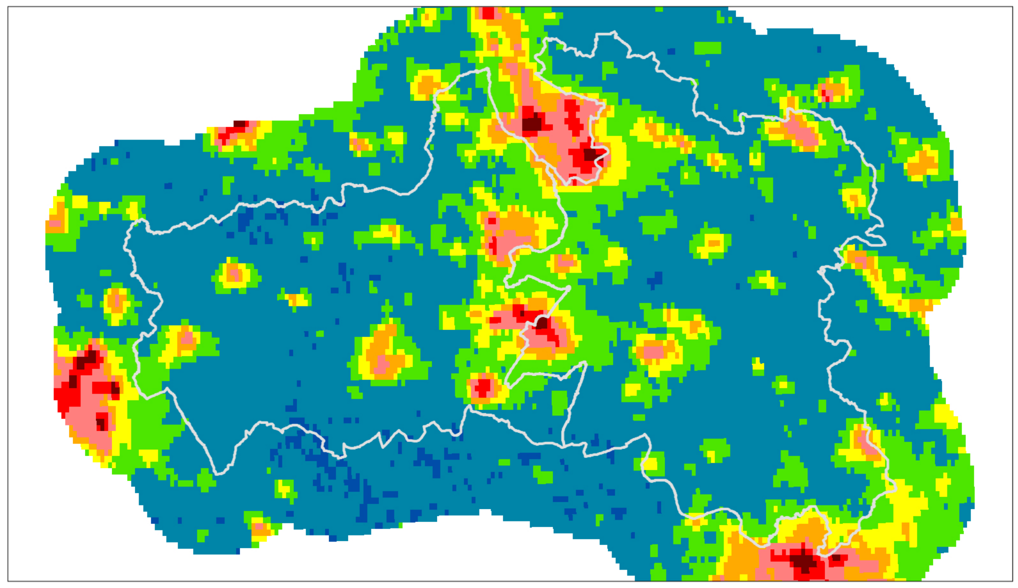
- 0
- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 +

Night lights (Nano Watts / cm2/ sr)

- <0.25 — Darkest
- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4 — Brighter
- 4 - 8
- 8 - 16
- 16 - 32
- >32 — Brightest

2022-10





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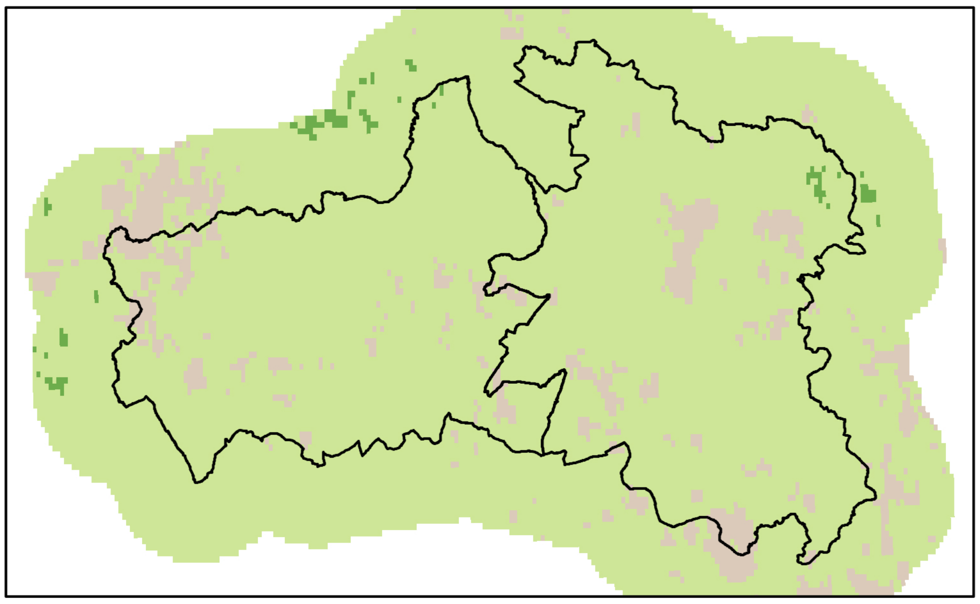

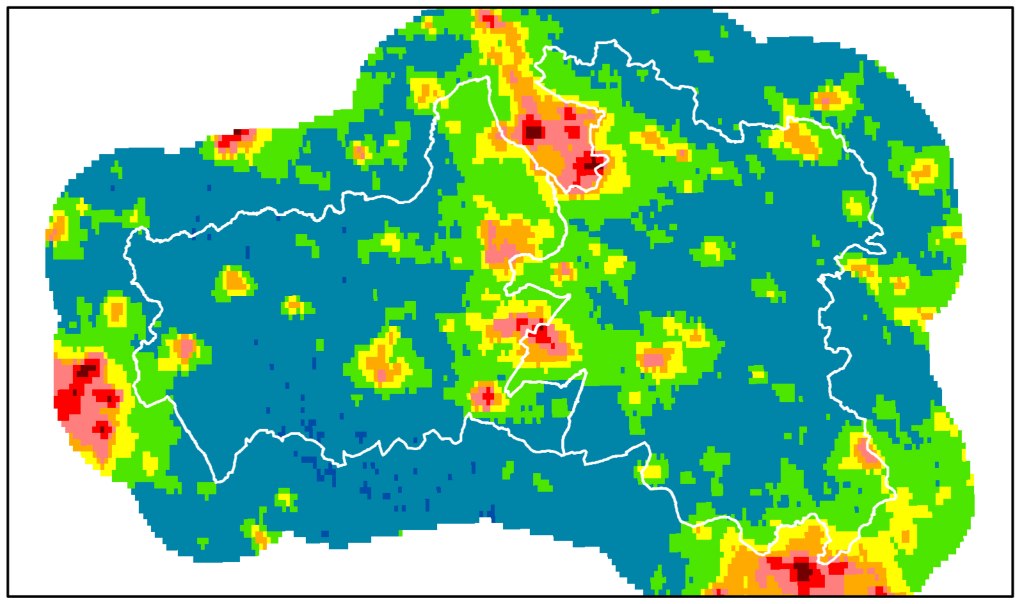

Earth Observation Group, NOAA National Geophysical Data Center 2022

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12315_r1_DarkSkies_Data_Selection_2022_10_11 16/05/2023
Source: Visible Infrared Imaging Radiometer Suite, (VIIRS) Dat/Nigt Band (DNB), Earth Observation Group, NOAA National Geophysical Data Center, Colorado School of Mines

N

0 50 100 km

Map scale 1:565,000 @ A3

2022 October and November cloud cover and radiance

Dark Skies Assessment
South Oxfordshire and Vale of White Horse

LUC

Cloud free days

- 0
- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 +

Night lights (Nano Watts / cm2/ sr)

- <0.25 — Darkest
- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4 — Brighter
- 4 - 8
- 8 - 16
- 16 - 32
- >32 — Brightest

Appendix C

Zero-point calibration coordinates

Table C.1: Zero-point calibration point coordinates (British National Grid)

Easting	Northing
412319.2	165407.0
417319.2	165407.0
422319.2	165407.0
427319.2	165407.0
432319.2	165407.0
437319.2	165407.0
442319.2	165407.0
450985.9	165394.4
457319.2	165407.0
463099.1	165570.5
466753.2	165092.5
472319.2	165381.8
487319.2	165407.0
412319.2	170407.0
417319.2	170407.0
422319.2	170407.0
427319.2	170407.0
432319.2	170407.0

Appendix C Zero-point calibration coordinates

Easting	Northing
437319.2	170407.0
442319.2	170407.0
447319.2	170407.0
452319.2	170407.0
457319.2	170407.0
462319.2	170407.0
482168.3	171979.3
412319.2	175407.0
417319.2	175407.0
422319.2	175407.0
427319.2	175407.0
432319.2	175407.0
437319.2	175407.0
442319.2	175407.0
447319.2	175407.0
452319.2	175407.0
457319.2	175407.0
461999.3	175259.4
476109.1	176539.0
482444.9	175414.9
487319.2	175407.0
412218.6	179778.1
417824.6	180412.3
422319.2	180407.0
427319.2	180407.0

Appendix C Zero-point calibration coordinates

Easting	Northing
432319.2	180407.0
437319.2	180407.0
442319.2	180407.0
447319.2	180407.0
452099.1	180836.7
457319.2	180407.0
462319.2	180407.0
467319.2	180407.0
472319.2	180407.0
477092.8	180394.4
482319.2	180407.0
422319.2	185407.0
427319.2	185407.0
432319.2	185407.0
437319.2	185407.0
442319.2	185407.0
447319.2	185407.0
452319.2	185407.0
457319.2	185407.0
462319.2	185407.0
467327.7	185463.6
472319.2	185407.0
477319.2	185407.0
482319.2	185407.0
486250.0	185545.4

Appendix C Zero-point calibration coordinates

Easting	Northing
411162.0	191363.0
417319.2	190407.0
422452.8	190388.5
427319.2	190407.0
432319.2	190407.0
437319.2	190407.0
442319.2	190407.0
447217.3	190524.7
452070.5	188676.6
457319.2	190407.0
463139.4	189884.4
467319.2	190407.0
472319.2	190407.0
477319.2	190407.0
482319.2	190407.0
487394.7	189841.0
412319.2	195407.0
417319.2	195407.0
422319.2	195407.0
427319.2	195407.0
432319.2	195407.0
437319.2	195407.0
442319.2	195407.0
447139.3	195371.3
452319.2	195407.0

Easting	Northing
457319.2	195407.0
462319.2	195407.0
467319.2	195407.0
472319.2	195407.0
477847.5	195054.8
482319.2	195407.0
486325.5	195960.5
412218.6	200721.5
417655.8	200913.4
422646.2	199954.2
427319.2	200407.0
432319.2	200407.0
437319.2	200407.0
442319.2	200407.0
447319.2	200407.0
452319.2	200407.0
457319.2	200407.0
462319.2	200407.0
467319.2	200407.0
472319.2	200407.0
477319.2	200407.0
482742.7	201256.1
485746.9	201363.0
412319.2	205407.0
417319.2	205407.0

Appendix C Zero-point calibration coordinates

Easting	Northing
422319.2	205407.0
426760.4	205426.0
432319.2	205407.0
437319.2	205407.0
442319.2	205407.0
446936.9	205563.1
457273.2	205634.0
463073.3	205835.6
467319.2	205407.0
472993.9	205010.1
477319.2	205407.0
481061.3	206438.4
486325.5	203960.5
412319.2	210407.0
417319.2	210407.0
422319.2	210407.0
427238.8	210316.0
432083.4	210597.5
438076.7	210542.5
442319.2	210407.0
447319.2	210407.0
452583.8	210457.3
457319.2	210407.0
462319.2	210407.0
467319.2	210407.0

Easting	Northing
472428.7	210446.7
477319.2	210407.0
481048.8	209463.6
488841.2	209891.3
412319.2	215407.0
417319.2	215407.0
422319.2	215407.0
427319.2	215407.0
432697.0	215316.0
437342.5	215334.0
442319.2	215407.0
446016.1	214084.1
452319.2	215407.0
457319.2	215407.0
462319.2	215407.0
467148.8	215458.4
472319.2	215407.0
477319.2	215407.0
483286.3	216214.2
488099.1	216438.4
411853.8	220394.4
417306.6	219488.8
422319.2	220759.2
427319.2	220407.0
432319.2	220407.0

Appendix C Zero-point calibration coordinates

Easting	Northing
437319.2	220407.0
442319.2	220407.0
447319.2	220407.0
452319.2	220407.0
457445.0	218784.4
462608.5	221413.3
467319.2	220407.0
472234.8	220318.6
477319.2	220407.0
482319.2	220407.0
487319.2	220407.0
411916.7	225142.8
416728.0	225407.0
422319.2	225407.0
427319.2	225407.0
432319.2	225407.0
437319.2	225407.0
442319.2	225407.0
447319.2	225407.0
452319.2	225407.0
457319.2	225407.0
462319.2	225407.0
466526.7	225583.1
472319.2	225407.0
477319.2	225407.0

Appendix C Zero-point calibration coordinates

Easting	**Northing**
482319.2	225407.0
487319.2	225407.0

Appendix D
Detailed method

Using satellite data to map light pollution

Suomi National Polar Orbiting Partnership (Suomi NPP)

D.1 The Suomi National Polar-orbiting Partnership or Suomi NPP is a weather satellite operated by the United States National Oceanic and Atmospheric Administration (NOAA). Launched in October 2011, the polar-orbiting satellite flies over any given point on Earth's surface twice each day at roughly 1:30 a.m. and 1:30 p.m. (local solar time). Suomi NPP orbits 824 kilometres (512 miles) above the surface as it circles the planet 14 times a day. Data is sent once per orbit to a ground station in Svalbard, Norway, and continuously to local direct broadcast users around the world. The mission is managed by NASA with operational support from NOAA and its Joint Polar Satellite System, which manages the satellite's ground system. Prior to the launch of this satellite, data on light radiance was available through the Defense Meteorological Satellite Programme (DMSP).

D.2 There are five instruments on the Suomi NPP satellite:

- The Advanced Technology Microwave Sounder (ATMS), a microwave radiometer, which models temperature and moisture for weather forecasting purposes.
- The Visible Infrared Imaging Radiometer Suite (VIIRS) captures visible and infrared imagery to monitor and measure processes including

wildfires, ice motion, cloud cover, and land and sea surface temperature amongst other things.

- The Cross-track Infrared Sounder (CrIS), which measures temperature, atmospheric moisture and pressure for weather forecasting.
- The Ozone Mapping and Profiler Suite (OMPS) collects data that is used to track the health of the ozone layer.
- The Clouds and the Earth’s Radiant Energy System (CERES) monitors the amount of energy entering and exiting the atmosphere.

D.3 Of the above sensors, the important one for this study is the VIIRS instrument which is described in more detail in the next section. The VIIRS collects low light imaging data and has several improvements over the previous satellite's (DMSP) capabilities.

Visible Infrared Imaging Radiometer Suite (VIIRS)

D.4 VIIRS is a scanning radiometer that collects visible and infrared imagery and radiometric measurements of the land, atmosphere, cryosphere (ice related), and oceans. VIIRS data is used to measure cloud and aerosol properties, ocean colour, sea and land surface temperature, ice motion and temperature, fires, and Earth's albedo.

D.5 The sensor collects data in a number of channels including:

- 5 High resolution imagery channels (I-bands)
- 16 Moderate resolution channels (M-bands)
- Day/Night Band (DNB)

D.6 It is the last of these that is of interest for this study – the Day/Night Band.

D.7 One of the major differences between the Suomi-NPP data and the DMSP-OLS derived data is the ground footprint. The Suomi-NPP VIIRS pixel footprint is 742m at nadir - the point on the surface of the earth directly below the satellite instrument.

D.8 VIIRS produces an image by repeatedly scanning a scene and resolving it as millions of pixels. The DNB sensor determines on-the-fly whether to use its low, medium or high gain mode to gather information on the amount of light emitted. If a pixel is very bright a low gain mode on the sensor prevents the pixel from over-saturating, by altering the exposure time. The opposite occurs if a pixel is dark.

D.9 In 2012, NOAA published the first image of nighttime lights for the earth using the Suomi-NPP VIIRS DNB derived data. This first global product used data captured between 18-26 April 2012 and 11-23 October 2012 to generate a composite image using cloud free images.

What can be measured?

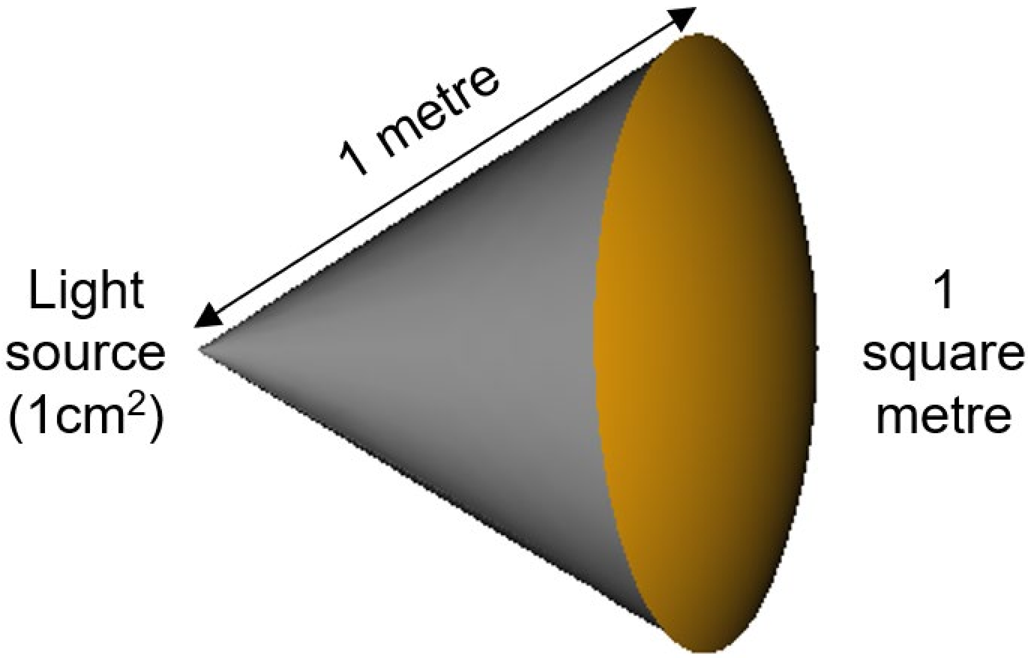
D.10 Whilst astronauts are able to take photos of the earth at night with a very high spatial resolution, a number of which have been widely publicised, they are limited to the orbit of the International Space Station which only passes over the same point every two or three days at variable times. Using the DNB data collected by the Suomi-NPP satellite, a daily picture is generated for every location at the same time every night (1:30am).

D.11 The VIIRS DNB sensor collects data in the spectral range of 500–900 nanometres (nm).

D.12 The radiance units are measured in nanowatts/cm^2/sr where sr is steradians. A steradian is a section of a sphere where the surface area is equal to the radius of the full sphere. It represents the surface area required by a detector to detect the full radiant flux (energy) at any given distance.

D.13 For example, if 1 square centimetre on the ground was emitting 1 nanowatt of radiant flux and the recording device was 1 metre away, it would require a surface area of 1 square metre in order to collect all of the energy from that nanowatt.

Figure D.1: Sensor measurements



D.14

D.15 As a further example, if 1 square cm on the ground was emitting 235 nanowatts of radiant flux and the recording device was 824 kilometre above the surface of the Earth (as the satellite is in this study), it would require a detector that is 824 square kilometre in order to fully absorb all 235 nanowatts. Since this satellite does not have detectors anywhere near that size, it instead measures the light that is detected by its detector and multiplies the size of that into the square 824 to get the measurement of radiance.

D.16 The reason for this is that the intensity of light falls off with the inverse-square of distance – the intensity of the light is proportional to the square of the distance between the emitter and the detector. For example; a detector at 2 kilometre from the light source would detect a quarter of the light one at 1 kilometre would. Just detecting the light falling on the detector would take into account both the intensity of the light being detected, and its distance from the detector. Calculating the radiance removes the distance variable.

D.17 It is worth noting that whilst the data captured by the Suomi-NPP DNB offers significant improvements over that of the DMSP data, the Suomi-NPP DNB lacks sensitivity at wavelengths shorter than 500 nanometres. Because of this, the blue-light emission peak of white LEDs is not detected. This means that the “blue blindness” of the VIIRS DNB could falsely suggest a reduction in light pollution in some towns and cities in the future, whereas the brightness of the sky as seen by human eyes may in fact increase. This is a known limitation of this data.

D.18 It will also be important to monitor advances in technology that will enable this end of the spectral range to be explored in future.

Obtaining data for this study

D.19 The algorithms and processes used to create the first 2012 image have been evolving and improving ever since. The Earth Observation Group (EOG) at Colorado School of Mines produces a Version 1 suite of monthly average radiance composite images using night time data from the Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB). Since January 2014, it has been possible to download monthly composites that have been filtered to exclude data impacted by stray light, lightning, lunar illumination and cloud cover.

D.20 These Version 1 composites span the globe and are produced in 15 arc second geographic grids as geotiff files. The globe is split into a set of 6 tiles (for storage, handling and processing purposes). Each tile includes two images:

- Average DNB radiance values, and
- Number of cloud free observations used to make the average.

D.21 The data are composited monthly, but there are areas of the globe where it is impossible to get good quality data coverages for some months of the year. Reasons for this include:

- Cloud cover (particularly in the tropics)
- Solar illuminations (particularly in areas near the poles in summer months).

D.22 There are two versions of each dataset which are created using different configurations. The first excludes any data impacted by stray light. The second includes these data if the radiance values have undergone the stray light correction procedure. The latter of these (stray light corrected) has more coverage towards the poles, and it is this set of data that has been selected for this study.

D.23 Data was downloaded from the Colorado School of Mines Earth Observation Group website **[See reference** 58**]**.

Processing the data

D.24 Data covering the study area is available as part of a larger tile covering 120 degrees of latitude (75N/060W) and reaching south to the equator. Bringing the data into GIS, the raw data has a geographic projection of WGS84 and the coordinates are latitude and longitude.

D.25 Data has been clipped in GIS to the study area boundary with an additional 6 kilometre buffer (so as to ensure the entire area is covered by complete pixels).

D.26 The pixel size of the original dataset was 15 arc seconds and was projected in WGS84. This projection distorts the shape of land areas the further they are from the equator, so Great Britain becomes more distorted the further north the pixels are. The southernmost pixel was 300m by 460m, and the northernmost 225m by 469m.

D.27 In order to make the data display properly within the web map it was necessary to project it to British National Grid (EPSG:27700). This involved resampling the pixels from 15 arc seconds to 400m x 400m cells – a value chosen as it falls between the minimum and maximum pixels size within the original data.

Appendix E

Full results of National Landscapes Analysis

Table E.1: Percentage of National Landscapes in each brightness category

Colour band	Chilterns	North Wessex Downs
Colour band 1a (Darkest)	43.32	47.56
Colour band 1b	42.98	31.90
Colour band 2	5.42	10.69
Colour band 3	4.66	5.22
Colour band 4	2.67	1.54
Colour band 5	0.82	0.43
Colour band 6	0.14	0.77
Colour band 7	0.07	0.86
Colour band 8	0.00	0.34
Colour band 9 (Brightest)	0.00	0.00

Table E.2: Area square kilometre of National Landscapes in each brightness category

Colour band	Chilterns	North Wessex Downs
Colour band 1a (Darkest)	101.12	88.96
Colour band 1b	100.32	59.68
Colour band 2	12.64	20.00
Colour band 3	10.88	9.76
Colour band 4	6.24	2.88
Colour band 5	1.92	0.80
Colour band 6	0.32	1.44
Colour band 7	0.16	1.60
Colour band 8	0.00	0.64
Colour band 9 (Brightest)	0.00	0.00

Appendix F

Parishes with no street lighting

F.1 **Figure F.1** shows the parishes with no street lighting of their own choice and the underlying Environmental Zones. These parishes are also listed in **Table F.1**.

Table F.1: Parishes with no street lighting

Parish number	Parish name
102	Adwell
108	Ardington
112	Ashbury
116	Aston Tirrold
117	Aston Upthorpe
118	Baldons
122	Baulking
127	Berrick Salome
135	Blewbury
139	Bourton
140	Brightwell Baldwin
141	Brightwell-cum-Sotwell
142	Britwell
147	Buckland
150	Buscot
158	Charney Bassett

Appendix F Parishes with no street lighting

Parish number	Parish name
160	Checkendon
172	Coleshill
174	Compton Beauchamp
180	Crowell
186	Cuxham with Easington
188	Denchworth
193	Drayton St. Leonard
198	East Hanney
200	Eaton Hastings
204	Ewelme
210	Fernham
217	Frilford
222	Garford
226	Goosey
228	Goring Heath
230	Grafton and Radcot
231	Great Coxwell
232	Great Haseley
242	Harpsden
244	Hatford
249	Highmoor
250	Hinton Waldrist
259	Ipsden
266	Kidmore End
269	Kingston Lisle

Parish number	Parish name
274	Letcombe Bassett
275	Letcombe Regis
277	Lewknor
278	Little Coxwell
280	Little Milton
283	Little Wittenham
284	Littleworth
285	Lockinge
286	Longcot
290	Lyford
292	Mapledurham
300	Milton
307	Newington
314	North Moreton
316	Nuffield
317	Nuneham Courtenay
322	Pishill with Stonor
324	Pusey
325	Pyrton
330	Rotherfield Greys
331	Rotherfield Peppard
338	Shellingford
344	Shirburn
356	South Stoke
357	Sparsholt

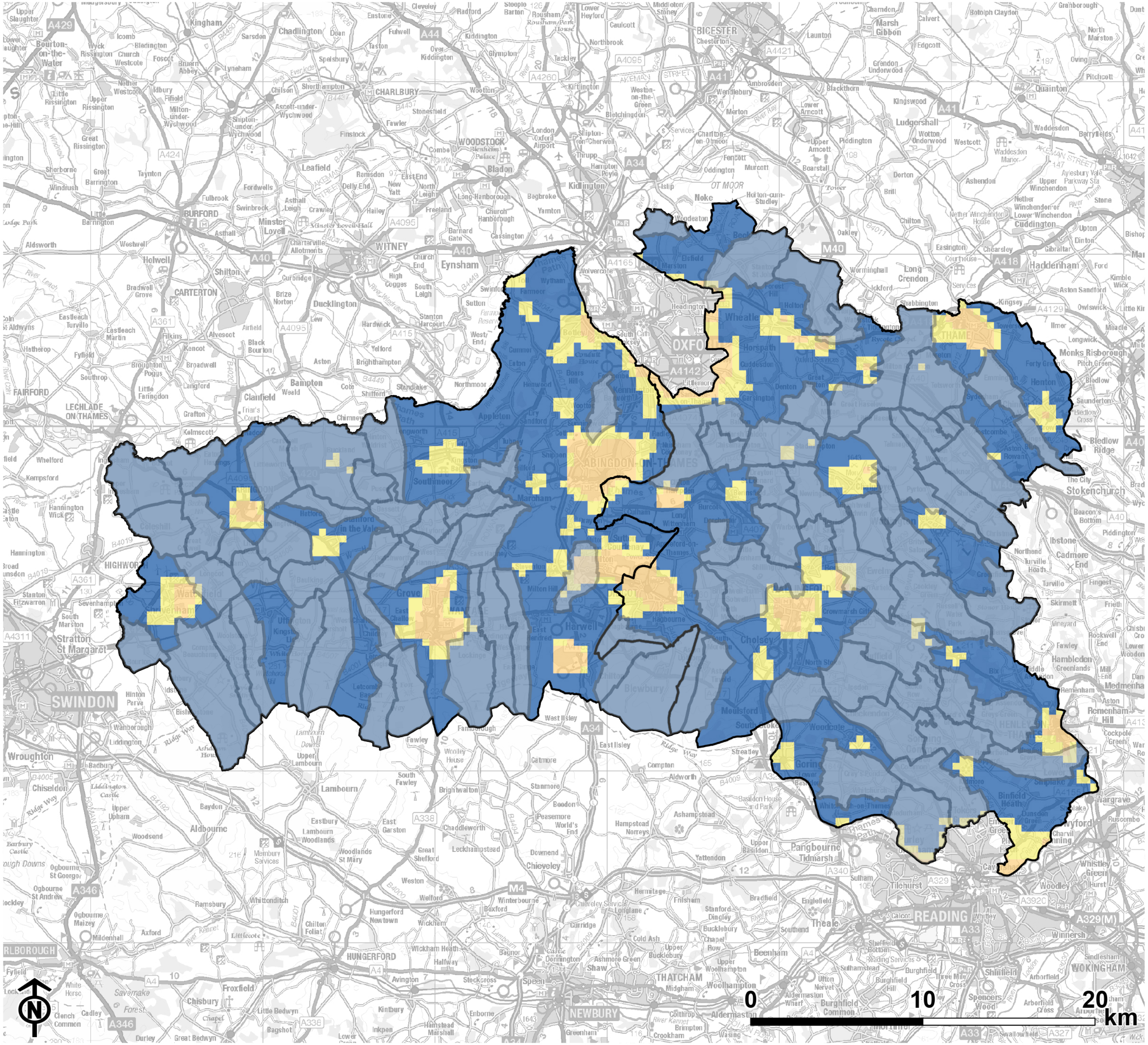
Appendix F Parishes with no street lighting

Parish number	Parish name
359	Stadhampton
363	Stanton St. John
368	Stoke Row
369	Stoke Talmage
372	Sunningwell
377	Swyncombe
378	Sydenham
382	Tetsworth
389	Upton
392	Warborough
395	Waterperry
396	Waterstock
399	West Challow
401	West Hagbourne
402	West Hanney
403	West Hendred
406	Wheatfield
412	Woodeaton
414	Woolstone

Dark Skies Assessment

South Oxfordshire and Vale of White Horse Councils

Figure F.1: Parishes with no street lighting



South Oxfordshire and Vale of White Horse

Parish with no street lighting

Environmental Zone

Natural dark zone (E1)

Rural low district brightness zone (E2)

Suburban medium district brightness zone (E3)

Urban high district brightness zone (E4)

Map scale 1:325,000 @ A4

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